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STUDIES ON THE EMBRYOLOGY OF BRUCHUS QUADRIMACULATUS, FABR.*

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INTRODUCTION.

Bruchus quadrimaculatus Fabr., is the weevil which is commonly known as the "Four-spotted bean weevil," but which is much more commonly found in shelled cow peas. The damage which is done to the peas is caused by the larvae of the weevils which spend their life in the seeds, feeding upon the cotyledons. On account of the rapidity with which the weevils multiply under favorable conditions a stock of peas in storage is quickly ruined by the burrowing larvae.

In this paper it is the writer's purpose to give an account of the embryonic development of the larva within the egg, thereby not only contributing to the better knowledge of this particular insect, but to the store of knowledge of insect embryology in general.

In the last three decades embryological and cytological research on the development of the insect's egg has proved particularly fruitful. The insects have yielded especially valuable information concerning the early segregation of the germ cells. Origin and development of the entoderm in the embryo has been a goal of many workers which as yet has not been reached. In addition to this nearly every new investiga-

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tion upon different insects yields particular information which varies more or less from the accounts of others on both closely and remotely related forms.

Before beginning a discussion of the embryology of this insect, a few preliminary explanations are probably necessary for an understanding of descriptions, and of references to methods employed.

For the present work weevils in large numbers were obtained in the seeds of cow peas purchased from a dealer in grain and seeds. Others of especially good egg laying qualities were obtained from Dr. J. K. Breitenbecher, of the University of Oklahoma, who for a number of years has employed this particular weevil in his genetic experiments. These stocks were kept in the laboratory under favorable conditions previously ascertained, and all references to the habits of the weevil refer to its habits when grown in the laboratory under these conditions. These are in all respects identical with its habits under favorable conditions on shelled peas in storage with the exception that the time required for the development of the embryo is probably somewhat shorter than is usual where development is on peas in storage.

Methods and Technique.

From the wild stock obtained from the dealer in seeds, female weevils with large long abdomens were usually selected. A number of these, together with a number of males, were put into test tubes containing kidney beans. Upon these the weevils deposited the eggs and in intervals of four to six hours or in some cases shorter intervals, the weevils were transferred to other tubes and the beans containing the newly laid eggs were incubated at from 33 to 35 degrees Centigrade, saturated humidity for the length of time desired. The eggs were then removed from the beans with a scalpel and were placed into the fixing agent. Kidney beans were used in preference to cow peas, because the color of the bean made it possible to see the eggs on their surface more readily. A stock of weevils was kept in the laboratory for a number of generations in jars of shelled cow peas, requiring only twenty days at 33 degrees C. to complete the cycle.

Bouin's picro-aceto-formol was used almost altogether as a fixing agent, although Petrunkevitsch's fluid was used in a few

cases. For stages of from seventy-five hours to one hundred hours, it was necessary to break the chitinous covering of the young larvae. This was done by means of Javelle water heated slowly to about eighty degrees C.

For much of the work the eggs with embryos were stained in toto with alum-cochineal, Mayer's carmalum, borax carmine, and picro-carmine. Alum cochineal was used with the most uniform success. After sectioning the eggs were often counterstained with Orange G. To check results, other eggs were stained with hematoxylin and counterstained with Orange G. This gave beautiful definition and cytological detail, but it was difficult to handle the unstained eggs during dehydration and embedding. The eggs were usually run in batches of from 20 to 30 eggs, in syracuse watch crystals.

Infiltration was accomplished without difficulty with toluol saturated with paraffin, and from this to two changes of paraffin for about fifteen minutes each.

Embedding was done on a hot plate, and the eggs were oriented with the use of a good lens. The importance of careful orientation of the egg in the paraffin block was soon realized. The sections were cut at from 7.5 to 10 microns, depending upon conditions.

I wish to acknowledge my indebtedness to those who by encouragement and criticism greatly assisted in the work. I am especially indebted to Dr. A. Richards of the University of Oklahoma, upon whose suggestion the work was undertaken and whose helpful suggestions and criticisms were invaluable factors in the work; to J. K. Breitenbecher, for assistance in the earlier experiments and for the cultures of weevils which he sent me; to W. D. Funkhouser, of the University of Kentucky, who gave me many helpful suggestions and was ever ready to discuss problems which presented themselves in the course of the work; and to Mr. S. J. Yabroff, who made and placed at my disposal a number of sections of cleavage stages.

Life History of the Weevil.

The eggs of the weevil are deposited upon and cemented to the surface of the shelled peas. Under the most favorable conditions the larvae emerge about one hundred hours after the egg is deposited. The larvae emerge on the side of the egg which is in contact with the pea, and as will be seen later this is really the dorsal side of the egg with reference to the developing embryo. The larvae upon emerging

from the egg eat their way directly into the pea, the place of entrance remaining covered by the chorion of the old egg. The larva requires approximately twenty-four hours for passing entirely from the egg into the pea. If the chorion is removed at this time the place of entrance of the larva may be seen with the aid of a lens or a binocular. At the time the larvae emerge they are about .5 mm. long. During the next ten days they grow very rapidly, feeding upon the peas. Four larvae are able to consume the entire contents of an average sized cow pea. In ten days the larvae have eaten their way back to the testa of the peas and here they pupate, lying just under the testa. The holes made by them may be seen at this time through the seed coat of the pea. In twenty days after deposition of the eggs the new generation of adult weevils emerges, through a circular opening made with the mandibles. The adults are about 3 to 4.5 mm. in length, the males being little more than half the size of the females, with short rounded abdomens, and are solid brown in color. The females besides being larger and having abdomens which extend posteriorly from under the wings, are of black or brown color with gray and white pubescence. They have four dark spots on the elytra from which the species derives its name. Horn's (1873) description of *Bruchus quadrimaculatus*, Fabr., is as follows:

"Elongate oval, moderately shining. Beneath equally clothed with whitish pubescence. Elytra ferruginous or pale brown, with large lateral spot and apex broadly black. Head dark brown or black, densely punctured, front sub-carinate. Antennae as long as head and thorax, serrate in both sexes, four basal joints pale rufous, outer joints dark and nearly black. Thorax trapezoidal, broader at base than long, sides distinctly arcuate, base trisinuate, basal lobe emarginate and clothed with whitish hairs; color variable from ferruginous to black, coarsely punctured, subgranulate and feebly shining, sparsely clothed with whitish hair. Elytra broader at base than thorax and longer than wide, sides feebly arcuate, humeri moderately prominent; striae punctured, intervals flat, densely punctulate; color ferruginous with large lateral spot and apex black, clothed with whitish and cinereous pubescence. Pygidium nearly black with median line of whitish pubescence. Body beneath piceous, densely punctulate and sparsely but evenly clothed with cinereous hairs; abdomen pale brown. Hind femora armed with an acute tooth on the inner side and a broad triangular tooth on the outer side. Length, 3 to 4.5 mm."

The males are at first probably more active. They seek out the females and copulation takes place shortly after emerging. A few hours later the female begins to deposit the eggs. The females are quite active at this time, crawling over and among the peas of the container. The female apparently has considerable difficulty ovipositing. The abdomen is carried low and she massages it with the metathoracic legs. She crawls a little farther and goes through the same performance. The micropylar or posterior end of the egg emerges first and this is cemented to the pea by a secretion exuded over it at this time. This cement around the edge of the egg causes it to appear larger than it actually is.

In previous experiments the optimum temperature for the development of the weevils was determined to be 33 to 35 degrees Centigrade and at a very nearly saturated humidity. The above chronology of development is true, of course, only for this temperature. Some of the first eggs studied were incubated at a temperature of 20 degrees, at which temperature it takes at least twice as long to reach a certain stage of development.

A summary of the experimental results on the oviposition of the weevil is as follows:

1. An increased temperature up to 35 degrees Centigrade accelerates metabolism. A higher temperature quickly results in the death of the insect.

2. The average number of eggs layed by one female is about 70. At a temperature of 33 degrees C. she lays this number of eggs in from three to five days. At a lower temperature the same number of eggs is deposited over a longer interval of time.

3. Oviposition takes place normally only after fertilization. Unfertilized females may deposit a few eggs during their life, but where this was the case the number of eggs deposited was far less than the average number deposited by fertilized females.

4. The activity of the female during the period in which eggs are deposited insures the distribution of eggs over a number of peas. Very frequently it was found that when only a pair of weevils were placed in a container for a twenty-four hour interval, none of the peas contained more than one egg.

Structure and Composition of the Egg.

When first deposited the eggs are viscid in appearance, but after the larvae emerge the shell which remains attached to the pea becomes chalky white. At first the texture of the integument is tough and elastic, but later it becomes quite brittle. Looking down upon the egg from above it appears to have the general shape of a hen's egg, or possibly it is more ovoid than a typical hen's egg. It is slightly more pointed at one end than at the other. A side view, however, shows it to be much flattened dorso-ventrally at the pointed end and much more rounded at the blunt end. The side in contact with the pea, however, is flat. The small end of the egg forms a funnel-like projection, the location of the micropyle. With reference to the embryo this is the posterior end of the egg, and the rounded end the anterior or cephalic one, and hereafter these terms will be used in designating these respective parts. Measurement of a number of eggs shows them to have an average length of .71 mm. The secretion which cements the egg to the surface, however, causes it to appear somewhat larger than it is when only the chorion is measured.

The egg is covered by two membranes, the chorion and the vitelline membrane. The former of these is tough and elastic and quite thick. The inner adheres closely to the egg content except at the micropylar end, where it projects out and is attached to the inside of the chorion around the micropylar opening, so that this opening passes through both membranes.

Within the chorion the cavity is not entirely filled by the deutoplasm and protoplasm. There is a space between the vitelline membrane and the chorion on the free side of the egg which is not entirely due to shrinkage incurred in fixation.

The egg content consists of two portions. The cytoplasm or formative yolk or ***Keimhautblastem*** of Weismann forms a homogeneous peripheral layer around the deutoplasm. This central yolk mass consists of a fine protoplasmic network containing vitelline spheres, vitelline bodies and larger and smaller fat globules embedded in a viscid cytoplasmic matrix, small in amount compared to the deutoplasmic material. Quoting Hegner, "This cytoplasm which is continuous with that of the cortical layer is entirely homogeneous, except at the posterior end, at which place in many insects inclusions have been discovered, which in the chrysomelid beetles take the form of a polar disc of granules, which I have called germ cell or germ line determinants." This description is in all respects also true of the weevil's egg. In the egg of ***Bruchus*** these inclusions occur in the form of a more dense area in the cytoplasm, but later in the form of a disc of granules which stains more densely.

Organization of the Egg.

At the time oviposition takes place before the egg has entirely left the vagina it does not appear as if the egg is flattened any more on one side than on the other, so that the dorsal and ventral surfaces cannot be distinguished. According to the law of orientation of insects the anterior end of the future embryo is at this time directed toward the head of the mother. In ***Bruchus*** this is true in the few cases observed. The anterior and posterior ends are therefore pre-determined before oviposition. It is not known whether the dorsal and ventral sides of the weevil's egg have also been determined at this time or not. According to the experiments of Wheeler of the development of the eggs of Blatta and those of Hegner on Chrysomelid beetles it is reasonable to suppose that in ***Bruchus*** the future dorsal and ventral sides of the embryo have at this time been determined also.

From the manner in which the egg is deposited, and the manner in which development later takes place, it is certain that ***Bruchus*** conforms to the "Loi de l'orientation de l'oef" of Hallez, namely, that the anterior, posterior, and right and left sides are determined as the egg is formed in the ovary, and that the future anterior end of the embryo is at this time directed toward the head of the mother.

It is most certain that in the weevil's egg different cytoplasmic areas are destined to give rise to particular structures in the future embryo, and that this is already true at the time the egg is deposited. As before stated, the eggs are attached to the surface of the peas regardless of the position of the pea or of the female weevil at the time of oviposition. Some of the eggs will appear on the upper, lower, or side surfaces of the peas. The experiments performed by Wheeler on the eggs of Blatta are duplicated by the weevils themselves in the deposition of the eggs. Gravity, then, can have no effect upon the development of the embryo as the position of the latter with reference to the egg is fixed regardless of position.

Cleavage and the Formation of the Blastoderm.

The position of the fertilization nucleus at the time cleavage begins is about midway between the dorsal and the ventral margins and somewhat nearer the micropylar end. (Fig. 1, N). The cleavage cells resulting from the first divisions of the nucleus appear at approximately the center of the egg. This group of cells is at first round in shape, but soon elongates and the cells undergo mitotic division and increase in numbers. At this stage a transverse section through the center of the egg shows the cleavage cells about equal distant from the periphery at all points. (Fig. 2, Cl. c).

The cleavage nuclei are usually spherical and are from 20 to 25 microns in diameter. They are relatively large for the cytoplasmic content of the cell. They contain a network of achromatic material which contains the granules of chromatin well distributed and not densely compacted. Although the granules stain deeply the entire nucleus has a lighter appearance than the cytoplasm surrounding it. This is true of the nuclei even after they enter the cortical layer up to the time the cells form a columnar epithelium in the blastoderm. The nuclei are surrounded by cytoplasm irregular and amoeboid in shape with one or more projecting processes, which causes them to occasionally appear stellate. They are without cell walls.

Nelson in the "Embryology of the Honey Bee" (1915) calls attention to the fact that the position of the cleavage nucleus within the cell is regularly central, but that as the cells approach the cortical layer their position is peripheral nearer the side which approaches the cortical layer. This has been noted in the cleavage cells of *Bruchus* and is shown in Fig. 5, Cl. C.

The cleavage cells during migration and immediately after their arrival at the cortical layer may be seen in various phases of mitosis (Fig. 2–6). The technical methods employed were not the best for cytological detail and consequently did not bring these out to best advantage. The phases appear to be similar to those found by Nachtscheim for the honey bee, (1913).

Wheeler (1889), for Doryphora, states that the cells resulting from the division of the original fertilization nucleus increase by mitotic division till there are about ninety before any reach the cortical layer. After reaching the cortical layer, however, these cells cease mitotic division. Although I have failed to find mitotic division in the blastema cells after they become more numerous, I have seen mitotic figures in this layer immediately after the arrival of the first cells. Present evidence does not warrant a conclusion as to whether or not they cease mitotic division.

As the cleavage cells approach the periphery of the egg they may be observed in cleared and stained entire mounts. Fig. 1, A, is a drawing made from a photograph of an egg at this time. This shows that the cells and their processes make up a syncytium at this time. The cells are at first more concentrated in a transverse band near the anterior end of the egg. Here they appear somewhat smaller than those of the

posterior end, where they are not in such close contact with one another. By the time the blastoderm is completed, however, there seems to be little difference in the development in that of the anterior and that of the posterior end, with the exception of those cells of the posterior extremity to which attention will be called in a later paragraph. Such a difference in development has been noted, however, as being true for Chalicodoma by Carriere and Burger (1897), and for the honey bee by Nelson (1915), but according to Henking (1892) does not appear in Lasius.

As the cleavage cells arrive at the cortical layer, it has been stated that the position of the nuclei within the cells is regularly peripheral, on the side of the cell which first approaches the layer. Moreover at this stage the nuclei frequently appear elongated or slightly flattened with their long axes parallel to the periphery and at right angles to the line of movement. Nelson calls attention to this in the case of the honey bee. It was also noted by Noack (1901) for Musca. The nuclei enter the cortical protoplasm along with the cytoplasm of the cell. The protoplasm of the cortical layer pushes up around the cytoplasm of the cleavage cell and between two adjacent cells, (Fig. 4). As the cells become more numerous they assume a cuboidal form due to the increased pressure around them. (Fig. 6). Slight indentations also appear at the periphery of the layer and push down between the cells, separating them from each other by furrows thus caused. As the cells continue to multiply they become more crowded, elongate, and change from cuboidal to columnar form, because of the increased pressure. Division occurs in more than one plane so that the nuclei become arranged in several rows. (Fig. 7).

The cells are now separated from each other by furrows, causing each cell to appear distinct. There are as yet, however, no cell walls. (Fig. 7). This stage is reached in from eight to twelve hours, and the exact time is apparently quite variable between these hours. In eggs incubated at 22 degrees Centigrade this stage is reached in about twenty hours.

At first there is no difference in the thickness of the dorsal and the ventral blastoderm. A difference is first noticed an hour or two before the first marks of gastrulation appear. Fig. 8 is a transverse section through the anterior end of an egg at this stage. Here the cells of the ventral blastoderm are well defined with definite cell walls. Their nuclei are arranged in a single row and the inner ends of the cells become vacuolated. The cells of the dorsal wall on the other hand have no walls, become flat and irregular and finally this side loses the evidence of its cellular origin.

At the posterior end of the egg the blastodermal cells do not develop as do those of the other parts. The blastodermal cells here remain somewhat spherical or slightly cuboidal. At this part of the egg the first cleavage cells to arrive enlarge in size upon their arrival, and continue to the extra blastodermal area. They increase their number by mitotic division, and form a large cluster of cells just at the posterior pole of the egg. (Fig. 13 and 18). This has been well described by Metschnikoff for Cecidomya as early as 1866, and by various workers between that

date and the present time. Noack in his paper "Beitrage Entwicklungsgeschichte der Musciden," describes the migration of these cells in some detail. More recently a complete history of these cells has been worked out in Chrysomelid beetles by R. W. Hegner. (1909). Hegner also demonstrates that the cells which develop into the pole cells and later become the germ cells, do so only after coming into contact with the germ cell determinants of the cortical cytoplasm, (Fig. 1). He further shows that the blastodermal cells of this region are prevented from normal development by the development of the pole cells.

In *Bruchus* these cells remain at this place during the formation and completion of the blastoderm, and for a short time after the appearance of the gastral invagination, (Fig. 13, G. C.), or until the lengthening of the germ band causes the posterior end of the band to bend around the yolk to form the caudal plate. Their migration from this time has not been studied in *Bruchus*. They are shown in Fig. 13 lying at the caudal end of the germ band. This section is a longitudinal one of this end of the band, but passes diagonally through the gastral groove.

This marks the completion of the formation of the blastoderm. It is completed in from 12 to 14 hours at a temperature of 35 degrees Centigrade. This is about one-eighth to one-seventh of the entire time required for the development of the larvae, at the end of which time the larva is completely fitted for independent existence. This is somewhat longer than the period required for blastoderm formation in Hydrophilus (Heider, 1889). In the latter this period is one-tenth the time required for complete development. Nelson in the "Embryology of the Honey Bee" calls attention to the long period of its formation in this insect. Here it occupies one-fourth the time for complete development.

The Vitellophags.

During their migration most of the cleavage cells reach the cortical layer, but a few remain behind. These become the yolk cells or vitellophags, which are seen in later stages. (Fig. 6). These cells increase in number by mitotic cell division and according to Hegner and Friederichs there is considerable evidence that they also multiply by amitosis. According to these investigators the mitotic figures of some stages are irregular. (Friederichs, 1906; Nelson, 1915).

Although the first yolk cells are formed from cleavage cells which fail to reach the periphery during migration, it has been shown that secondary yolk cells are also formed by a migration of cleavage nuclei from the blastoderm after its formation. Patten in Neophylax (1884) and Korotneff in Grylotalpa (1885), found that all cleavage cells were formed in these insects entirely by migration of cells from the blastoderm.

The migration of yolk cells from the germ band to the yolk was first discovered by Graber in 1871, and later by him in 1883 and 1888. This was also established for Musca by Voeltzkow in 1889 and by Noack for Musca in 1901.

It becomes the function of these cells to liquify the yolk for the use of the cells of the developing germ band. It was formerly thought that

they were the entoderm cells and constituted the elements for the epithelium of the mid-intestine. (Babretzky, 1878; Weismann, 1882; Graber, 1878).

The Formation of the Germ Layers.

In from fourteen to eighteen hours after deposition of the egg the cells of the ventral blastoderm acquire a distinct cell wall and increase greatly in length at the expense of the underlying yolk which is liquified for their use by the vitellophags. The cells of the blastoderm also become closely crowded together on this side and become much vacuolated on their inner half. Many of the cells are now pyramidal in shape. The dorsal blastoderm on the other hand becomes very narrow and loses evidence of the cellular origin. This change produces a ventral plate which occupies the entire ventral surface of the yolk from the anterior to the posterior end of the egg. A transverse section at this stage through the thickened plate shows the cells to be highly columnar in the center, tapering down gradually at the sides where the last few cells on each side become pyramidal at the point of junction with the thinner dorsal strip. (Fig. 9). This point of junction also marks the rudiment of the amnio-serosal fold, which is soon to envelop the entire embryonic rudiment. (Fig. 9, Am.). This ventral plate is the rudiment of the future germ band. At this time appears an invagination of cells in the ventral plate to form a median longitudinal groove, appearing first near the anterior end and extending posteriorly till it reaches the posterior extremity. This groove appears in Figure II and is shown in transverse section at a slightly earlier stage in Figs. 10 and 13. This is the gastral invagination and yields the lower layer or plate of cells, (Figs. 10, 11, 12, m. p.). The ventral plate may now be called the germ band. It grows rapidly in length at this time and cannot be accommodated by the size of the egg on the ventral side of the yolk.

At the anterior end the germ band broadens out laterally to form the cephalic lobes, and at the same time extends dorsally around the anterior end of the yolk. At the posterior extremity it flexes dorsally and cephalad completely around this extremity back to about two-thirds the distance to the anterior extremity on the dorsal side of the yolk to form the caudal plate. (Fig. 15, C. Pl.).

In his account of the gastrulation of Doryphora, Wheeler notes that the gastral groove is deeper nearer the posterior extremity than at the anterior end. Previous to reading Wheeler's paper I had noted it in series of transverse sections through the ventral plate of *Bruchus*, but had supposed it to be due to the earlier closing of the groove at the anterior end. Upon re-examining the sections, however, it was quite apparent that the groove is wider, deeper, and persists longer in the posterior region than in the anterior one.

At the time the ventral groove is formed and after a middle mesodermal plate has been formed the amnio-serosal folds appear at the sides of the germ band. (Fig. 12 and 15. Am. Sr.). At the posterior end it grows back around the caudal plate, and at the anterior end it appears at the sides of the cephalic lobes and grows over the anterior

end of the band, and from the lateral edges of the germ band, (Fig. 11), it grows ventrally until the entire germ band is covered by it and the dorsal food yolk is completely surrounded by its dorsal extension and thus brought into the embryonic rudiment. In Bruchus the ventral amnion lies in immediate contact with the cells of the germ band, so that in many transverse sections the flattened cells of the amnion can be noticed only where there is a depression in the germ band. In many insects, Hemiptera and Lepidoptera, (Korschelt and Heider, Text-book of Invertebrate Embryology), the space between the amnion and serosa becomes filled with particles of food yolk to form an *immersed germ band*.

In structure the amnion and serosa is a delicate, transparent veil which adheres quite closely to the embryo except at the anterior and the posterior ends, where it fits more loosely. In sections the cells are much flattened, but are still large enough to distend the cytoplasm of the folds which cover them. Nelson has likened the cells of the amnion of the honey bee to beads strung loosely on a thread. This description would also apply to the amnion cells of Bruchus.

As the ventral groove again closes by the coming together of the *lips* of the *blastopore* to which the ventral edges of the groove correspond, the invaginated cells are pinched off, as it were, become spherical or elliptical and form a plate of cells just under the columnar ectodermal cells. Unlike the case of Doryphora and Donacia, a tube is never formed by the closing of the groove in Bruchus. The cells from this middle mesodermal plate push out laterally to form a layer of flattened mesodermal cells inside the ectoderm. (Figs. 10, 11, 12, Mes. and M. P.).

The method in which the mesoderm is formed differs greatly among insects and has been classified by Korschelt and Heider as follows:

1. The formation of a tube by invagination of a medial strip of the ventral blastoderm. This tube, constituting the mesoderm, may be thick-walled and round in section (and consequently possess only a narrow lumen as in many Coleoptera), or thin-walled and compressed in a dorso-ventral direction, as in Chalicodoma, (Carriere, 1890). This type is probably the most common and best known of the three. Patten found it in representatives of widely separated orders, for example, Hydrophilus, (Kowalevski, 1871), Musca (Kowalevski, 1886), Pyrrhocoris, (Graber, 1888), Chalicodoma, (Carriere, 1890).

2. The middle plate remains nearly flat and is overgrown by the edges of the lateral plates, which become free. This type is relatively uncommon, but is also found in representatives of widely separated orders, as in Apis, Sphinx, (Kowalevski, 1871), Pieris, (Bobretzky, 1878), Gasterophysa, (Lecaillon, 1897), and in a slightly modified form in Forficula, (Heymons, 1895).

3. The mesoderm arises from proliferation and immigration from a median area of the ventral blastoderm. A median groove is often present. This type approaches the conditions obtained in the apterygota, (Heymons, 1897), and appears to be especially characteristic of the Orthoptera, being found, for example, in Gryllotalpa, (Korotneff,

1885), Phylodromia (Cholodkowski, 1891), Gryllis, Periplaneta (Heymons, 1895).

Although the mesoderm is formed in *Bruchus* chiefly by this invagination of cells as in Hydrophilus, there is also a delamination of cells of this medial plate, as shown in Fig. 10, taken from a transverse section near the center of the germ band. It has also been shown that the classification cannot be considered as of great systematic importance, as closely related forms may differ in the manner of germ layer formation, as for example, Apis and Chalicodoma.

Coincident with process of mesoderm formation is that of segmentation. This is well defined in the anterior portion of the germ band at the time the median groove is formed and is shown in Fig. II, where it is evident by the slightly wavy or indented margin. In other entire mounts it may be seen in the form of alternating light and dark transverse bands. It is evident that the segments appear first in the anterior region and thence in rapid succession from the anterior to the posterior ends and simultaneously on both sides of the germ band. The segmentation of the embryo is marked in longitudinal sections, where slight indentations appear in the ectoderm to mark off successive segments. The mesoderm is notably thickened in these segments and thinner just over the indentations (Fig. 15).

The Mesenteron.

The origin of the mesenteron of insects has been the subject of investigation for fifty years. According to the germ layer theory the tissue from which the mesenteron is formed should correspond to the entoderm of the various animals. The efforts of the many investigators on this subject has been directed toward establishing a homology between the entoderm rudiment or better the mesenteron rudiment and the third layer of entoderm derived in the gastrulation of other animals. This has been a difficult task. In 1882 Weismann wrote as follows: "It becomes more and more evident that nowhere in the animal kingdom is the ontogeny so distorted and coenogenetically degenerate as in the insects so that scarcely anywhere are the germ layers so difficult to recognize as here." (After Nelson "The Embryology of the Honey Bee").

Prior to 1884 there were three important theories as to the development of the mesenteron. First, that of Dohrn, according to which the mesenteron was derived from the yolk cells or cleavage cells remaining in the yolk and taking no part in the formation of the blastoderm. (1866). Second was that of Kowalevski, according to which the mesenteron was derived from the splanchnic layer of the mesoderm. (1871). Third, that of Ganin, (1874), who described the mesenteron as arising from the inner ends of the stomodaeal and proctodaeal invaginations.

In 1886 Kowalevski in a paper on the origin of the mesenteron rudiments on Musca, described them as arising from the anterior and posterior parts of the middle mesodermal plates. He compared the conditions found in this insect with those of the arrow worm

Sagitta. He regarded the insect egg at the time of gastrulation as comparable to a much elongated gastrula, in which the entoderm was pulled into two halves. These views were also held by Wheeler and Cholodkowski, and by Korschelt and Heider. Voeltzkow, and Graber, however, contended that the mesenteron arose from the blind inner ends of the stomodaeum and of the proctodaeum. In 1895 Heymons, who in his development of the Orthoptera and Dermaptera, gave special attention to the development of the mesenteron, also found that it was derived from the blind inner ends of the stomodaeal and proctodaeal invaginations. This has been confirmed by investigators in the Coleoptera, Lepidoptera and Orthoptera.

According to Carriere and Burger in the mason bee, Chalicodoma, the anterior and posterior mesenteron rudiments arise from proliferating areas of the undifferentiated blastoderm at the two ends of the ventral plate and independent of it. These rudiments form two large hemispherical masses with their convex surfaces directed inward. Later the superficial layer of these rudiments is modified to form ectoderm, except a small area just over the center of the anterior rudiment, which remains unmodified and actively proliferating, and which is to form the stomodaeal invagination. They insist on the independence of the mesenteron rudiments from the mesoderm, and consider those parts of the ventral plate from which they arise as blastodermal.

Noack's (1901) observations on Musca are similar to those of Carriere and Burger on Chalicodoma, namely, that the mesenteron arises independently of the mesoderm. His statement which is very definite, is as follows: "Wahrend sich aus dem Mittelstuck des Keimstreifens in der eben geschilderten Weise das Mesoderm entwickelt, entsteht aus dem vorderem und hinteren Keimstreifenende die Mitteldarmlage."

Nelson in the "Embryology of the Honey Bee" finds evidence that the anterior mesenteron rudiment is derived from the cells of ventral blastoderm by immigration and that this rudiment is continuous with and comparable to the ventral plate and that the source of the posterior mesenteron is obviously the posterior end of the ventral plate.

At the time of the appearance of the mesenteron rudiments in *Bruchus* the mesoderm is spread out under the ectoderm and may be seen to be made up of two layers as in Fig. 15. There is at this time a marked thickening of cells under the caudal plate (Figs. 15 and 16). At this portion of the caudal plate the gastrula groove has at this time not yet closed. According to Wheeler in his paper "The Embryology of Blatta and Doryphora," this thickening of cells in Fig. 15, which is essentially the same as that of his Fig. 82 for Doryphora, is the source of the posterior rudiment. As stated above, however, the gastral invagination has not yet closed on the caudal plate, and these cells may well be considered as having arisen from undifferentiated cells from the blastoderm. (Fig. 16).

The origin of the anterior mesenteron in *Bruchus* presents still another difficulty. Here a thickened mesoderm area over the stomodaeal invagination as described by Wheeler for Doryphora has not been

determined. In fact the mesodermal cells come to an abrupt end a little distance below the stomodaeal invagination. The cells which lie over the ectodermal cells at the stomodaeum are cells of the anterior mesenteron rudiment. (Figs. 14, 15). It may be seen that the origin of these entoderm cells could have been attributed to the cells of the stomodaeum at the time that invagination occurs, but it is also likely that they have been formed by a cutting off of cells from the high blastodermal cells before this invagination occurs.

From these two mesenteron rudiments the lining of the mid-intestine is formed by a migration of cells from these two rudiments. The circumcrescence of the yolk is accomplished by a dorsal and ventral proliferation and migration of the elements. The anterior rudiment projects caudally into the open body cavity and two small masses of cells may be seen inside the arms of the germ band in a transverse section through the anterior thoracic region. A meeting of the cells from the anterior and the posterior rudiments seems to take place first on the dorsal side of the yolk. The enclosing of the yolk is first accomplished by a row of isolated cells from these rudiments. These cells become more numerous and finally form a layer of cuboidal cells around the yolk. (Figs. 19 and 30).

Development With Reference to Shape and Body Form.

Carefully stained and cleared mounts of entire embryos yield much information concerning the development of the external features which cannot be obtained from sections, although there is much difficulty in getting the embryos stained to exactly the right degree to show all features equally well. For this reason the figure shown is a composite drawing of an embryo obtained from several mounts of embryos incubated for the same length of time, but which showed different features to better advantage.

The stomodaeal and proctodaeal depressions appear early as triangular depressions. The cephalic lobes from which are derived the three lobes of the brain, as well as the optic lobes are indicated clearly. The brain is directly continuous with the ventral chain of ganglia seen at each side of the median line of the embryo. At this time the caudal end of the embryo is still flexed around the posterior pole of the egg. In from twenty to thirty hours, however, the embryo begins to shorten markedly. The caudal plate is withdrawn till it lies just at the posterior pole of the egg. At the same time the embryo, which has been a rather narrow band on the ventral side of the yolk, begins to broaden till it occupies the entire ventral surface, and the edges of the germ band turn dorsally to begin a circumcrescence of the food yolk. (Fig. 17). Cross sections through the abdominal part of the embryo show it to be in the shape of a horse shoe with the two arms grasping the yolk. This circumcrescence is however not completed till quite late in the development of the embryo.

The embryo now appears as in Fig. 20. It is seen to taper at both ends, but more at the posterior than at the anterior one. The widest part of the embryo is the thoracic region where the three thoracic

segments appear to be equally wide and from this region the segments quickly become narrow. The embryonic envelopes which cannot be shown cover the entire embryo like a transparent curtain. On the embryo itself at the anterior end in a median line is the heart-shaped labrum dorsal to the stomodaeum. Just lateral and ventral to this are the large mandibles. The antennae project from under the mandibular rudiments and at this time lie in line with the mouth. Just posterior to the mandibles are the first and second maxillae which already appear segmented.

Showing very clearly on the ventral side of the embryo is the chain of ventral ganglia which already show the darker cellular part, and the lighter parts of the commissures or fibrous part. The appendages do not show distinctly in these preparations, but they appear on the thoracic segments and are all approximately the same length. The tracheal invaginations are located just at the base of the legs.

The Nervous System.

Shortly after the gastrular invagination closes the rudiments of the ventral chain of ganglia may be observed as a marked ectodermal thickening at each side of the median ventral line and they extend from the last abdominal segment forward to the cephalic region. These primitive swellings are separated at the outer margin by the primitive groove which pushes up between them. At the anterior end of the embryo, these swellings pass to the sides of the stomodaeal invaginations and the oesophagus and are continuous with the cephalic lobes. The ventral cord and the brain rudiments are thus continuous from the first.

A study of the primitive thickenings shows the cells at first to be all alike. In a short time, however, the cells of this area become drawn out and their threads intermingle. This causes the chain of ganglia to be very conspicuous in an entire mount at this stage. (Figs. 17, 19, 20, 30).

Since the chain of ganglia is formed from the outer ectoderm it is naturally continuous with it at first and continues to be for some time. Separation from the outer ectoderm or the hypodermis begins soon after forty hours or perhaps even sooner in the region of the brain masses and progresses from the anterior to the posterior extremity. For a long time, however, this separation from the hypodermis is only partial, as the outer layer of cells of the ganglia and the cells bordering the primitive groove, *Mittelstrang*, remains continuous with the outer ectoderm. (Fig. 17).

The brain develops in the anterior region of the cephalic lobes as early as 26 to 30 hours. Like the brain of other insects this is composed of three paired ganglia, called by Viallanes the protocerebrum, the deutocerebrum, and the tritocerebrum. (Fig. 21, B1, B2, B3). This segmentation was first discovered and described by Patten (1884). These lobes are first in the form of paired thickenings at the sides of the stomodaeum into the anterior cephalic region, and are directly continuous with these thickenings. Due to the flexure of the germ band which occurs in *Bruchus* around the anterior pole of the egg, the first

brain segment or protocerebrum becomes directed caudally. This brain segment is divided into three lobes, which according to Viallanes (1891), and Wheeler (1893), are destined to form the following: the first lobe forms the optic lobe; the second the optic tract, and the third a part of the brain included in the protocerebral lobes; the deutocerebrum is continuous with the circum-oesophageal commissures, and is less distinct than the other segments of the brain.

When first formed the rudiments of the two halves of the brain are distinct from each other, and lie apart from each other. Later as the brain is shifted to the dorsal side, the two halves are brought nearer together and a commissural connection between them is established.

The brain, like the remainder of the nervous system, being ectodermal, is at first continuous with the ectoderm. It becomes separated from this at 45 to 50 hours by delamination, as occurs between the ectoderm and the ventral chain of ganglia.

The Tracheal System.

The first tracheal invaginations appear shortly after the rudiments of the appendages in the anterior end of the body, and then in succession on each of the segments posteriorly. They appear just lateral to, and at the base of these rudiments in the anterior part of the segment. (Fig. 20). These invaginations are quite shallow at first, spreading out somewhat just under the ectoderm to form a shallow sack. (Fig. 22). From these invaginations diverticula are sent out in four directions. One dorsally, one ventrally, one anteriorly and one posteriorly. The anterior and posterior diverticula of two successive segments fuse to form a longitudinal trunk, the dorsal and the ventral diverticula of two successive segments fuse to form a longitudinal trunk, the dorsal and the ventral diverticula form transverse commissures between the longitudinal trunks and at the same time break up into many ramifying twigs. These trachea are at first slender intercellular tubes formed by rows of cuboidal ectodermal cells. (Figs. 23 and 30, Tr.). It is not till from 75 to 80 hours that the chitinous lining of the tubules is shed by the bordering cells. The transverse threads of this chitinous lining, known as the taenidia, may be recognized in the tracheae at 80 hours. From this time till the time of hatching it is probable that the tracheal system is filled with air as the eggs containing the larvae from this time do not sink in the liquid reagents as they formerly did and special treatment is necessary to prepare them for sectioning.

The Tentorium.

This chitinous structure is derived from ectodermal cells which are invaginated from the outer ectoderm shortly after the rudiments of the mouth parts appear. (Fig. 24). The number of these invaginations varies in different insects, depending upon the parts of the tentorium present in the adult structure of these insects. In the embryos of some insects it does not become chitinous, but remains in the form of intercellular tubes, as is the case in the honey bee. Nelson, (1915).

In *Bruchus* the parts of the tentorium are as follows:

1. The body of the tentorium, (Fig. 25, Tnt. 1, 2).
2. Dorsal arms, (D. Tnt.).
3. Anterior arms, (Tnt. M.), and a frontal plate, (F. Tnt.).

The invaginations from which this is formed appear to be three in number on each side of the head, and appear at thirty-two to thirty-five hours. One of these pairs of invaginations is located at the base of each of the first and second maxillae. Those of the maxillae may be seen in a cleared and stained entire mount. The invaginations from the maxillae grow inward, broaden and deepen, that from the first maxillae medially and cephalad. At this time they are in the form of ectodermal tubes. These two pairs of invaginations meet between the sub-oesophageal ganglion and the oesophagus to form the body of the tentorium. (Fig. 25). At the same time the invaginations from the base of the mandibles grow medially and caudally soon to meet the body of the tentorium. From this invagination is formed the mandibular apodemes of the tentorium. The dorsal apodemes of the tentorium arise from the outer end of the body of the tentorium. They push upward between the mesodermal cells and each bows medially and meets that of the other side on the median line of the head. Other attachments for muscles also develop as outgrowths from these primary parts.

The invaginated structures are originally tube-like, but become flattened and as the different parts fuse, form a lamellar structure, the sides of which are composed of flattened ectodermal cells which retain the staining characteristics of the cells of the outer ectoderm. At sixty-five to seventy hours the mesodermal cells of the head are undergoing metamorphosis to form the various sets of muscles of the head. (Fig. 26, Tnt.). The tentorial apodemes can at this time be readily distinguished from the cells of other structures.

The chitinous tentorium found in the mature larva is formed in *Bruchus* simultaneous with the shedding of the cuticle by the ectodermal cells of the hypodermis. Little remains to suggest the cellular nature of its origin. At the time it is first formed it may be fixed and sectioned readily. Later, however, it is quite impenetrable to fixing agents and requires special treatment.

The tentorium not only serves as the supporting structure of the head but its various arms are the attachments for muscles of the head. To the mandibular apodemes are attached the flexor mandibulae, and opposing muscles. From the dorsal arms muscle fibers pass to the hypodermis of the head, and from the inner margin of the dorsal arms the dilators and constrictors of the pharynx are attached.

The tentorial invaginations appear to be homologous to the tracheal invaginations of the body segments, arising as they do at the base of the appendages of the head as the tracheal invaginations do in relation to the body appendages. They were considered to be homologous to the latter structures by Hatschek, (1877), by Wheeler, (1889), and by Carriere and Burger, (1897). Nelson, however, has discovered a pair of invaginations in the honey bee in addition to the tentorial invaginations, in the first maxillary segment on the lateral surface of the anterior

half of the segment, above the base of the rudiment of the second maxilla. This discovery would exclude the homology of the tracheal and tentorial invaginations.

The Alimentary Canal.

The alimentary canal consists of the following parts: the short narrow oesophagus, curved dorsally and caudally and leading from the buccal cavity to the much enlarged mid-intestine, and a short slightly curved hind intestine. The stomodaeal depression which has already been alluded to, appears at 26 to 28 hours as a cup-shaped depression just under the labrum and above and between the mandibular rudiments. Just back of the mouth opening the oesophagus is slightly enlarged to form the pharynx. During the formation the oesophagus pushes posteriorly into the mid-intestine and becomes invaginated into it. (Fig. 28).

The mid-intestine constitutes by far the larger part of the alimentary canal and occupies the greater part of the body cavity. (Fig. 30). In transverse sections it is seen to be bounded by the arms of the germ band on the ventral and lateral sides and by the serosa on the dorsal side. In early stages in the posterior end it is bounded on the dorsal side by the caudal plate of the germ band which has come to lie on the dorsal side of the yolk. At the anterior end it opens into the oesophagus but it is at first completely closed at the posterior end. In the fully developed larva it is cylindrical in shape and extends from the first to the eleventh body segments. Its walls are thin, but the cells of the mucosa of the adult larva are large and cuboidal in shape with spherical nuclei. The cytoplasm of the cells is granular like that of secretory cells. (Fig. 30).

The lining of the mid-intestine is derived from the anterior and the posterior rudiments and has already been described.

The proctodaeum is short and slightly flexed. At an early stage in its development, 35 hours, it gives off three pairs of diverticula which become the Malpighian tubules. These appear while the proctodaeum is quite shallow, (Fig. 31), and for a brief period open directly on the external surface. At first these lie lateral to the proctodaeum, (Fig. 31), but later become arranged equidistant from each other around the intestine. The lumen of these tubes is at first very small. Wheeler describes the origin and growth of these tubules for Doryphora, which appears to be very similar for *Bruchus*. The tubules are at first carried cephalad by the forward growth of the proctodaeum. The tubules themselves grow out until they come into contact with the body wall, then grow forward till their blind ends come to lie far forward in the abdomen. Similar results have been noted in a number of forms, some of which are the following: Doryphora, Wheeler (1889); Chalicodoma, Carriere (1890); Gasteroidea, Hirschler (1909); Apis, Nelson (1915). In Chalicodoma and in Apis the tubules appear before the proctodaeum, as pit-like depressions at the posterior end of the germ band.

The Dorsal Body Wall.

At approximately 75 hours the amnion and the serosa become separated from each other. By this time the arms of the germ band in the thoracic and abdominal regions of the larva have reached the dorsal level of the food yolk, which has become somewhat contracted. The cells of the amnion appear to be disintegrating and are very likely responsible for a clump of material likened to the "Dorsal organ" of those forms in which it occurs. (Wheeler, "Embryology of Blatta and Doryphora"). The food yolk in the region of this activity is rapidly being broken down by the action of the vitellophags which are also bringing about the liquifaction of the so-called dorsal organ. From this time it is but a few hours till the cells of the hypodermis of the germ band arms have completed the circumcrescence of the yolk and thus closed the entire dorsal body. By this time also the migrating cells of the mesenteron rudiments have encircled the yolk mass to complete the closure of the mid-intestine. The cells of this mid-intestinal mucosa on the ventral side of the body lie in close contact with the ventral ganglia and lateral to this lie close to the body wall. (Fig. 19). This figure shows the completion of the dorsal body wall and the structures of the coelome as well as the completely closed intestine. The cells of the hypodermis are at this time quite flat. Just under the hypodermis on the ventral lateral side the cells of the somatic mesoderm are undergoing metamorphosus to form the muscle fibers of the oblique muscle band. The splanchnic mesoderm lies in close contact with the entoderm of the intestine and the cells have not yet undergone metamorphosis. In the body cavity is seen a section of longitudinal tracheal tube, as well as a number of free mesodermal cells with clear nuclei and containing large fat globules. This is the rudimentary fat body which in the immature embryo remains in this form.

At this time just dorsal to the mid-intestine is a double row of cells, which in cross section have a crescentic shape with their horns directed toward each other. These are the cardioblasts. These cells come together, the horns of the crescents fuse to form the dorsal longitudinal tube, the heart. In Figures 19, C. B. they are seen to enclose large clear cells which become the blood cells. Korschelt and Heider have established these to be mesodermal cells. (Korschelt and Heider, "Text-book of Invertebrate Embryology").

The fate of the embryonic envelopes varies somewhat with different insects; probably in the majority of cases they are taken into the body and absorbed with the yolk. Wheeler (1889) for Doryphora observes that the amnion is thus absorbed in that insect, but that the serosa remains intact around the embryo till torn by the emerging larva. In the honey bee where the amnion is the only envelope present this remains until torn by the movements of the emerging larva. (Nelson, 1915).

In *Bruchus* the two envelopes separate from each other during the later stages of development. The amnion recedes into the body cavity with the remainder of the food yolk and is probably responsible for a

clump of material seen in some sections. (Fig. 19, D. O.). Here it is absorbed after being broken down by the action of the vitellophags. The serosa, however, is not taken into the body, nor does it remain about the embryo, but undergoes a fatty degeneration in situ.

After the dorsal body wall is closed a number of changes take place in the external form of the body. The embryo in the first place becomes more cylindrical in form (Fig. 30). Heretofore it has been in the shape of a boat. Only at the anterior and the posterior ends has it been cylindrical, and even here it was more flattened on the dorsal side. The ventral line from the anterior to the posterior end was convex, but now the embryo becomes ventrally flexed like the mature larva. After seventy-five hours the larva is seen to move head and trunk quite actively within the egg. These movements may precede the movements of emerging or they may be part of them.

The only rotation which the embryo undergoes in the egg is the rotation during emerging. It has been seen that the ventral side of the embryo is uppermost in the egg during development. The head of the embryo is in the rounded end of the egg and the mouth-parts are turned upward away from the pea to which the egg is attached. The place of emerging is on the flat surface of the pea, which is the surface in contact with the pea. In order to reach this the larva is compelled to flex the head and thorax dorsally or downward, while the posterior part of the body still retains its normal flexure. The larva is therefore in the shape of a letter "S," shown in Fig. III.

The process of emerging is a slow one, as the larva eats its way into the pea. Emerging begins at ninety-six hours and lasts approximately twenty-four hours. The embryo is partly in the egg and partly in the pea during this interval. Its solid wastes are excreted into the egg and fill the greater part of the space left there.

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Plate XIII

Fig. 1. Median longitudinal section of egg before fertilization. N. nucleus, Cortical cytoplasm, P. D. Polar disc of cytoplasm.

Fig. 2. Transverse section of egg showing cleavage cells before reaching cortical layer. C. L. Cortical layer. Cl. C. Cleavage cells. × 330.

Fig. 3. Section of periphery of egg with two cleavage cells in two phases of entrance into cortical layer. C. L. Cortical layer. Cl. C. Cleavage cell. × 700.

Fig. 4. Cleavage cells in cortical layer showing nuclei of these cells and their cytoplasm, and the less dense cytoplasm of the cortical layer surrounding these cells. Cl. C., Cleavage cell. C. Cy. Cortical cytoplasm. × 700.

Fig. 5. Cells of the developing blastoderm becoming cuboidal with furrows appearing at their outer margins. Cl. C. Cleavage cell undergoing mitosis at this time. × 700.

Fig. 6. A section of the blastoderm slightly more advanced than in Fig. 5. This shows the cells cuboidal in form, separated from each other by furrows. Cl. C. Cell undergoing mitotic division. Vit. Vitellophag. × 700.

Fig. 7. Transverse section of egg showing blastoderm completed. Cells are separated by furrows. Indications of cell walls appear on their free edges. There is little difference in the height of the cells of the ventral blastoderm and those of the dorsal blastoderm. V. Bl. Ventral blastoderm, D. Bl. Dorsal blastoderm. × 330.

Plate XIV

Fig. 8. Transverse section of egg. Blastoderm complete and cells of ventral blastoderm becoming crowded. Dorsal blastoderm on other hand becomes thin and the cells very much flattened. D. S. Dorsal Strip. × 300.

Fig. 9. Transverse section of egg in anterior region. Cells of ventral blastoderm become highly columnar and vacuolated. Cha., Chorion. V. Pl., Ventral plate. × 330.

Fig. 10. Transverse section through gastral invagination near posterior end of ventral plate. G. Inv., Gastral invagination. Mes. Mesoderm rudiment. × 700.

Plate XV

Fig. 11. Transverse section through center of egg, after closing of the gastral invagination. Ect., Ectoderm. Mes., Mesoderm. Am. Sr., Amnio-serosal fold. × 330.

Fig. 12. Transverse section through posterior part of germ band. Ect., Ectoderm. Mes., Mesoderm. C. Pl., Caudal plate. Sr., Serosa. Am., Amnion. × 330.

Fig. 13. Longitudinal section of germ band, showing pole cells. G. inv., Gastral invagination. P. C., Pole cells. × 330.

Plate XVI

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Fig. 15. Longitudinal section of embryo of 32 hours. A. M., Anterior mesenteron rudiment. Stm., Stomodaeum. Mes., Mesoderm. C. Pl., Caudal plate. Sr. Serosa. Am., Amnion. P. M., Posterior mesenteron rudiment. × 330.

Fig. 16. Transverse section through caudal plate. Sr., Serosa. Am., Amnion. G. inv., Gastral invagination. P. M., Posterior mesenteron rudiment. × 700.

Plate XVII

Fig. 17. Transverse section through thoracic region of 36 hour embryo. L. R., Limb rudiment. Ect., Ectoderm. V. gang., Ventral ganglion. Coel., Coeleme. A. M., Anterior mesenteron rudiment. × 330.

Fig. 18. End view of egg of 14 hours. P. C., Pole cells. Bl., Blastoderm.

Fig. 19. Transverse section through thoracic region of embryo of 65 hours. D. O., Dorsal organ. C. Bl., Cardioblasts. F. C., Cell of fat body. Ent., Entoderm. S. Mes., Somatic mesoderm. Sp. Mes., Splanchnic mesoderm. Hyp., Hypodermis. Tr. Trachea. Ob. Mcl., Oblique muscle. Gng., ganglion. × 330.

Fig. 20. Entire embryo of 32 hours. Lbr., Labrum. Ant., Antenna. Mnd., Mandible. Mx. 1., First maxilla. Mx. 2, Second maxilla. V. Gng., Ventral ganglia. Prct., Proctodaeum.

Plate XVIII

Fig. 21. Longitudinal section through head of 32 hour embryo. B. 1, B. 2, B. 3, First, second and third brain lobes respectively. Fr. Gng., Evagination of frontal ganglion. × 330.

Fig. 22. Section through tracheal invagination. L. R., Limb rudiment. Tr. Inv., Tracheal invagination. × 330.

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Fig. 26. Transverse section through head of 72 hour embryo. Tnt., Tentorium. Mcl., Muscle cells. × 330.

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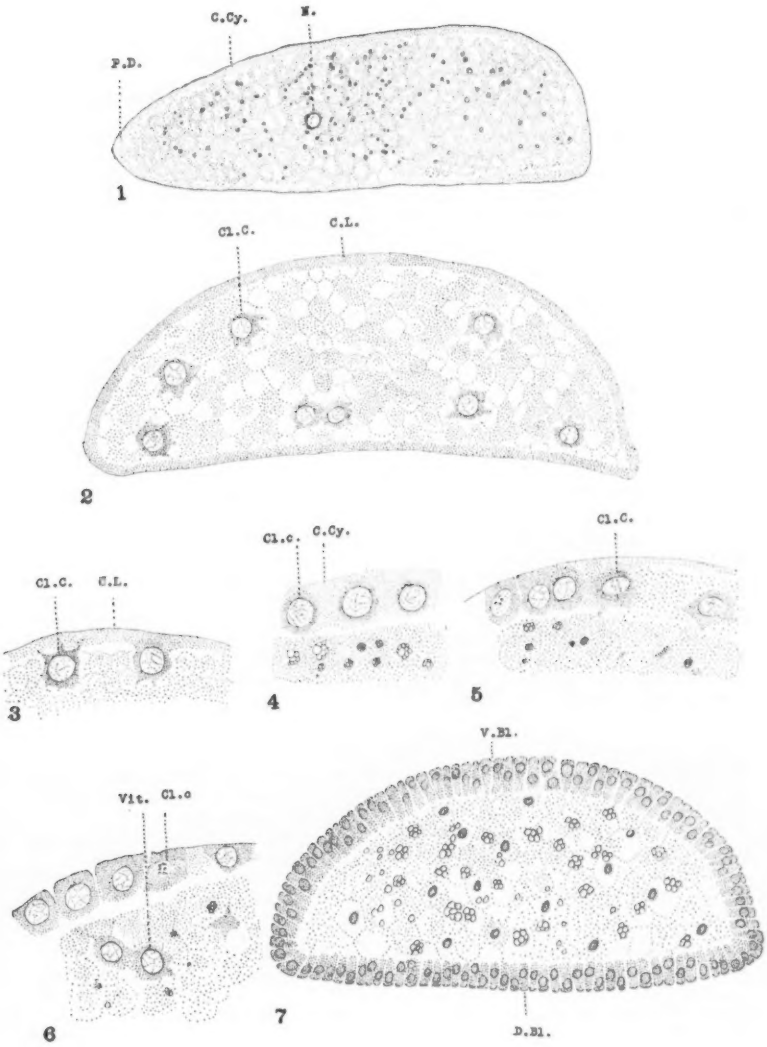
Fig. 29. Sagital section through proctodaeal invagination. Prct., Proctodaeum. Mlp., Malpighian tubes. × 700.

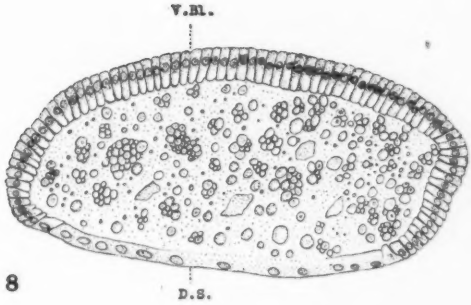
Plate XIX

Fig. 30. Transverse section through thorax of 90 hour embryo. Ht., Heart. Ent., Entoderm. Tr., Trachea. Ob. Mcl., Oblique muscle. F. B., Fat body. Gng., Ganglion. × 400.

Fig. 31. Transverse section through proctodaeum of young embryo, showing Malpighian tubes. Mlp., Malpighian tubes. Prct., Proctodaeum. × 330.



Alfred Brauer



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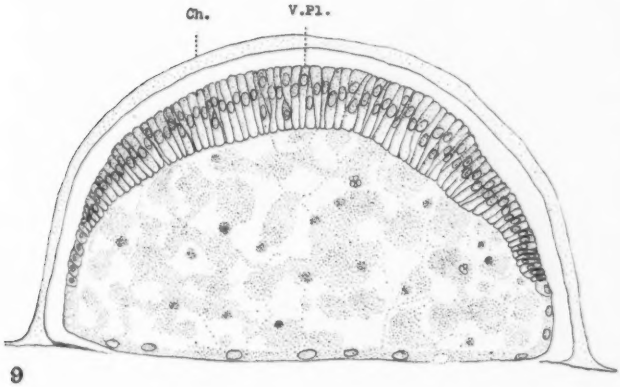

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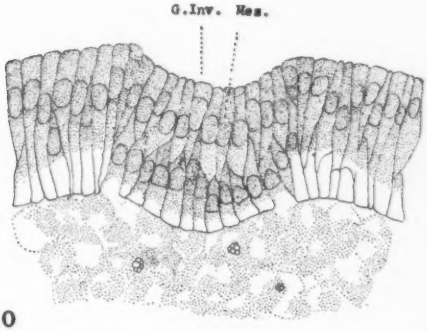

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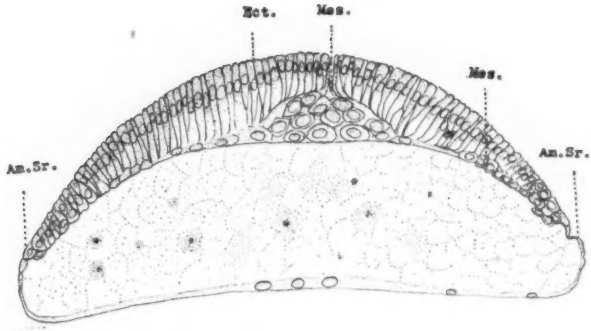

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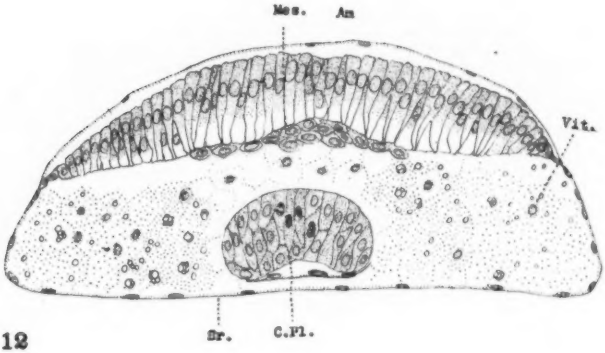

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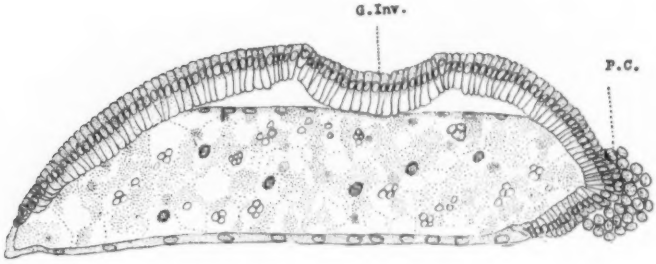

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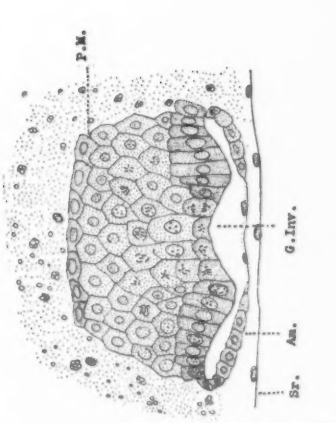

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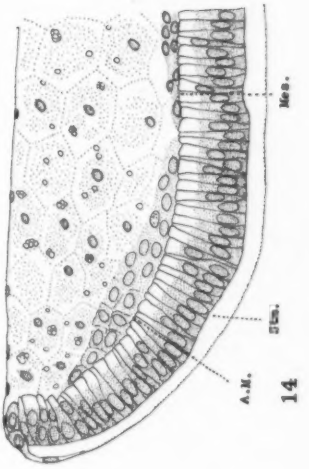

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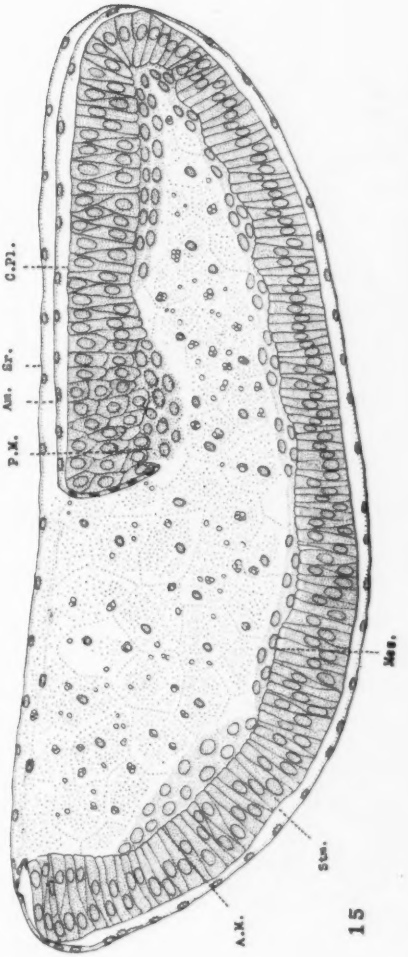

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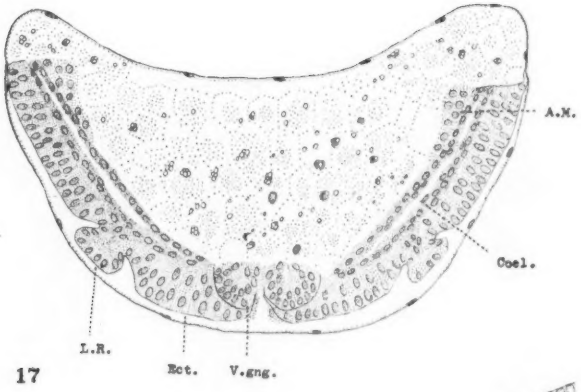

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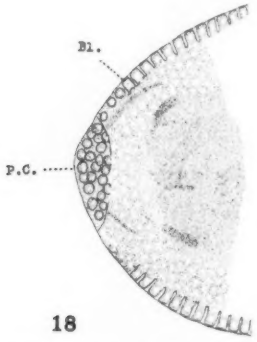

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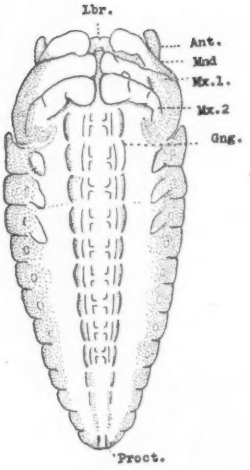

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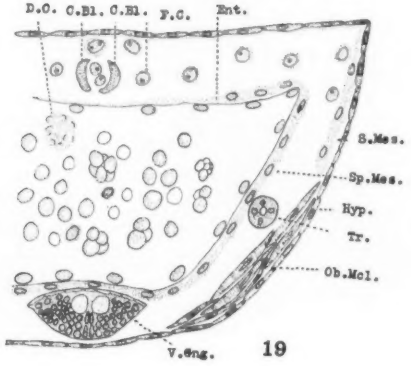

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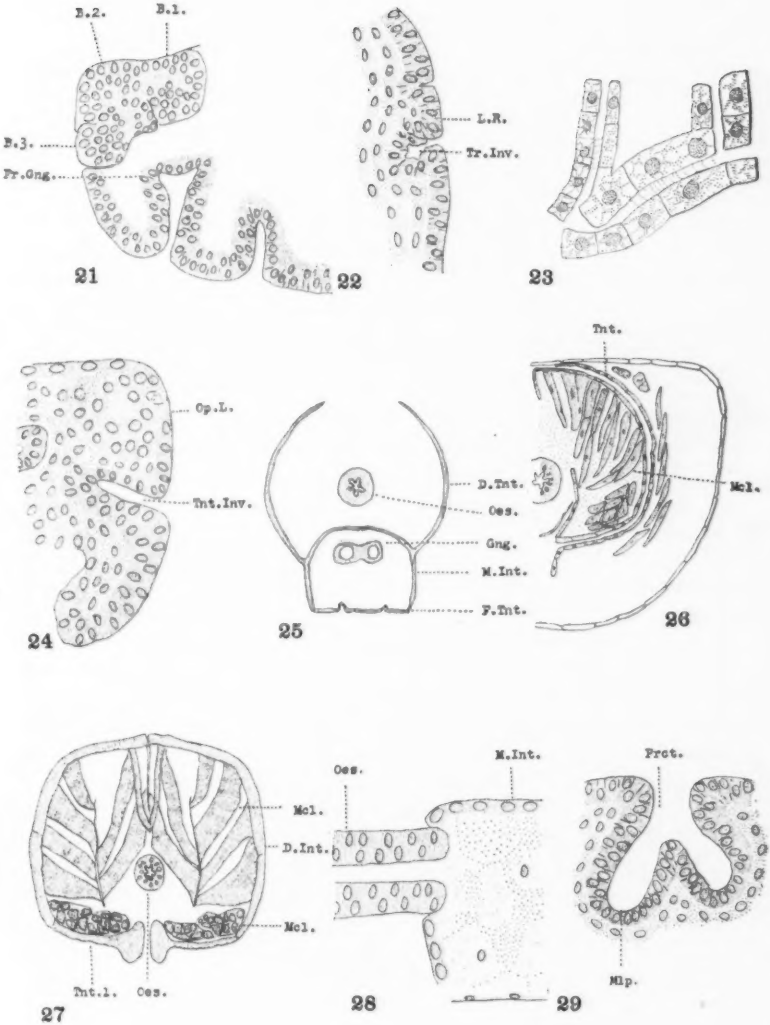

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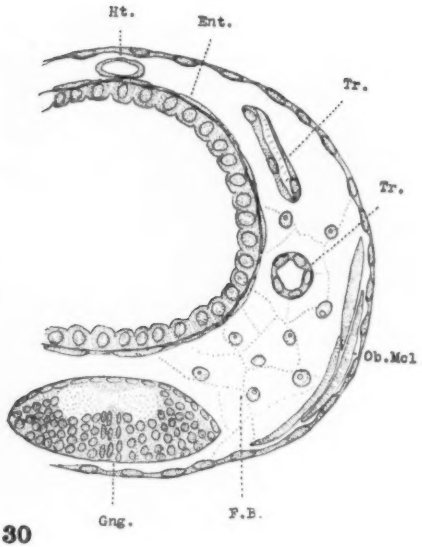

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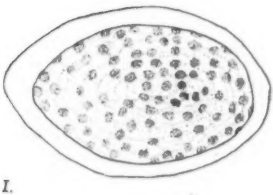

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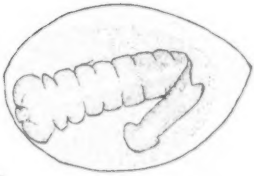

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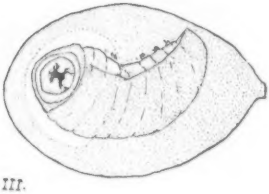

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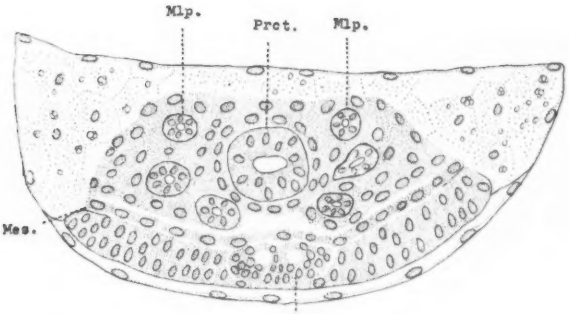

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Alfred Brauer

DESCRIPTIONS OF NEW OR INADEQUATELY KNOWN AMERICAN SPIDERS.

ALEXANDER PETRUNKEVITCH
Yale University

INTRODUCTORY REMARKS.

With the advance of our knowledge of the Spider fauna of the American continent it becomes more and more necessary not merely to add new species to the list of those already known, but to systematize and to review carefully work done in the past. Correct identification of a specimen, placing it in a species already known and not new to Science is in itself by no means always simple. Whenever good drawings are available, identification is at least reasonably possible. Yet even then one has to know the characters which the discoverer of the species considered to be sufficient for the definition of the genus, as otherwise one is forced to compare the specimen with the descriptions of a number of species belonging to related genera. Many genera as conceived by their creators have since proven to be too broad in their characterization. They had to be limited, the type species remaining as the type of the genus in its new limitation, other species becoming types of new genera. If every author describing new species were careful enough to give at the same time his conception of the genus, one were enabled to know many of the characters of the species. This method has the advantage of brevity and has been followed by Simon and F. O. Pickard-Cambridge. Even then not all species can be again recognized. The reason is simple: an author has usually a limited collection at his disposal. Within that limitation his distinction of species is valid. But the discovery of new species from other localities changes the value of the characters on which the distinction was based, the same characters often occurring in several species. Then the question arises, did the known species possess all the characters of the genus or did they not? If the text does not give any information in this regard, a condition soon arises when an old species may equally well be placed under two or more genera, unless indeed one has access to the type specimen and can thus use it as a

supplement to the description. Naturally, the trouble is still greater if the description is altogether inadequate, when the species may never again be recognized.

But mere identification of species can scarcely be an end in itself. If that were all there is to the Science of Taxonomy, it would amount to very little indeed. A detailed knowledge of the characters of a species is imperative for any comparative study, and the more detailed the description is, the more useful it may become. Such descriptions were given by Thorell and Keyserling and many others. Yet even such descriptions are not always exhaustive, a fact sufficiently evident when we recall to mind that a number of Keyserling's species cannot now be placed in the amended genera, because Keyserling either overlooked some important character or did not attribute to it sufficient value at the time when he described the species. The best way would be, of course, to review every family, giving careful definitions for each genus and minute descriptions of each species. We possess such a paper in Chamberlin's review of the Lycosidæ. But an investigator has not always time to limit his study to a single family, nor has he always the material to do so. Meanwhile he invariably comes across new species and such as have never been adequately described. It seems of distinct advantage to all engaged in the study of spiders to give careful descriptions of such species.

In the series of articles of which the present is the first I purpose to give such descriptions of new and known species as I happen to meet with in my work. In some cases the descriptions are based on a single specimen, no other specimens being available. In other cases one specimen is described in great detail and the others are used to point out the variations in size, color and structure. In some cases the description of young spiderlings is added to emphasize the change due to age and not to specific distinction. Whenever no other reference is made to the definition of the genus it is assumed that the genus is in full agreement with the definition given by Simon in his Historie Naturelle des Araignees. For the definition of the Families I refer to my own paper On Families of Spiders. To avoid unnecessary delay no attempt will be made at present to systematize the matter, except as occasion may arise.

A few words about the terminology to be followed throughout the series of these articles. I use the terms dorsal and ventral

in the morphological sense, applying them to laterigrade as well as to prograde spiders. In all cases the middorsal line together with the mid-ventral line determine the plane of symmetry in the body in the appendages. Left and right will be applied only to the body and an entire appendage, as left palp or right chelicera. In all appendages I use the term prolateral for the surface nearest the anterior end of the longitudinal axis of the body, and retrolateral for the surface nearest the posterior end of the same axis. My promargin of chelicerae corresponds therefore to the inner margin of tarantulae or upper margin of common spiders, while my retromargin corresponds to the outer margin of tarantulae or lower margin of common spiders. My prolateral surface of a leg corresponds to the inner surface of the first and second leg and outer surface of the third and fourth leg, while my retrolateral surface corresponds to the outer surface of the first and second, or inner surface of the third and fourth leg of either side. The upper surface of a laterigrade leg is morphologically the prolateral surface.

All measurements are in millimeters. The segments of the legs are measured with the aid of an ocular micrometer from the point of the proximal articulation to the point of the distal articulation. The curvature is not taken into consideration. In the case of the tarsi the measurement is taken from its articulation with the metatarsus to the base of the claws. The arrangement of spines and bristles is a most troublesome problem to handle. I use not Simon's but a somewhat modified Keyserling's method which seems to me to give a better picture. For example, middorsal 1–1–1 means that there is a single row of three spines in the middorsal line. Middorsal 1-1-2 means that the last two spines form a pair. Middorsal 1-0-1 means that the two spines are far apart because of the absence of the middle spine, which may be present on some other leg. Prolateral 1–1–2 means that the distal two spines are one above the other. A comparison of a great number of species with regularly arranged spines shows that with rare exceptions there are usually only two rows of spines on each surface. Lateral spines are often visible either from above or from below and have been consequently sometimes erroneously described either as dorsal or as ventral spines. Since with the exception of the patello-tibial articulation there are always two dorsal articulating points at each end of a segment, straight lines connecting these points clearly delimit the dorsal surface. The

ventral surface is never clearly delimited, but the rule that only two rows of ventral spines may be present, helps us to distinguish the lateral spines. In some cases safe distinction becomes impossible and has to be omitted. Unfortunately this system does not take into consideration the actual position of a spine on a segment in reference to its distance from the end or from the middorsal or midventral line. A few additional words are therefore often necessary and are introduced in parenthesis.

The measurement of the eyes also requires some elucidation. It is accomplished with the aid of an ocular-micrometer under a power varying from 35 to 50 diameters. In oblong eyes the figure refers to the long axis, in round eyes to the diameter of the cornea. Since spiders possess an iris and the pupil alone is often visible in artificial light, care must be taken to bring the outer edge of the iris into view. The measurements are not approximal, but exact, a diameter means a diameter, a radius—a radius. The actual size of the eyes or of the distances between them is not given. But the ratio is expressed in figures which refer to the number of divisions on the scale. Thus AME : ALE : PME : PLE — 8 : 9 : 8 : 10 means that the respective diameters occupy 8, 9, 8 and 10 divisions of the micrometer scale. At first I thought that it would be of advantage to recalculate all measurements, referring them to the AME as a unit of comparison, so that the above formula would read 1 : 1.125 : 1 : 1.25, but I soon found that there is an advantage in leaving the original measurements as they bring out certain relationships which otherwise are lost. The length of an eye-row, as well as that of the quadrangle is measured from outside vertex to outside vertex, not from center to center of the eyes. The term quadrangle always refers to the space occupied by the AME and PME. In Lycosids I speak of the Quadrangle of posteriors.

In measuring with a micrometer ocular care must be taken to keep the organ which is to be measured in such a position that it would be completely in focus from end to end as otherwise the measurement will not be correct. A goniometer ocular is used both for the measurement of angles and whenever an imaginary line has to be drawn through a pair of eyes. All figures have been made with the aid of a camera lucida. This is the reason why the measurements do not always coincide with the drawing of the eyes, because the latter appear in the drawing in a projection.

Family CTENIZIDAE.

Aptostichus flavipes n. sp.

Female. (Figures 1, 2 and 12).

Total with chelicerae—17.5 mm. Carapace 6.545 long, 5.610 wide in its widest region, 4.250 wide in front. Thoracic groove transverse, slightly procurved, deep and narrow, about as long as a third of the width of the carapace. Surface of carapace entirely glabrous except for a few hairs near posterior end and a median row of black bristles in front of thoracic groove. Head elevated. Eye group almost marginal in position, with a few bristles in front of AME, more than twice as wide as long. Anterior row straight, posterior slightly recurved. PME oval, opalescent, slightly converging. Ratio of eyes AME : ALE : PME : PLE—5 : 11 : 6 : 7. AME separated from each other by their diameter, from ALE by a little less. Both rows equal in length. Laterals separated from each other by the radius of the PLE. PME wide apart and separated from PLE by the radius of the latter. Quadrangle wider behind than in front (25 : 16), twice as wide as long. AME separated from anterior margin of carapace by 6/5ths of their diameter. Chelicerae powerful, covered above with black bristles, Rastellum composed of numerous black stout spines. Promargin with 7 large black teeth, retromargin with 7 small teeth. Scopula on retromargin well developed, composed of long greyish yellow hair. Scopula of promargin very poorly developed, composed of short hair. Lip wider than long, rounded, apparently immobile, as there is no true articulation line, but only a wide depression between lip and sternum. At end of lip a few capsules and long brown hairs. Coxae of pedipalpi longer than wide (65/45), thickly covered with capsules all way up to their end. Scopula rather light, of brown hair. Inner apical angle of coxae covered with stiff curved dark brown hair. Sternum longer than wide, gradually narrowed anteriorly to the width of the lip, widest between second and third coxae, pointed between fourth coxae, which are contiguous. Three pairs of poorly visible sigilla, third pair largest, oval, separated by its length from margin. Sternum clothed with brown, stiff, erect hair. All coxae also clothed with similar hair, with a single median stripe remaining bald in basal half of the first and second pair and two bald stripes in basal half of the third and fourth pair. First and second tarsus and metatarsus scopulate to base. Third and fourth without scopula. Legs short, stout and spiny, 4123.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	3.825	2.465	2.125	2.040	1.445	11.900
II	3.400	2.465	1.955	1.870	1.360	11.050
III	2.805	2.380	1.445	1.955	1.190	9.775
IV	3.995	2.890	2.975	2.975	1.615	14.450

No spines above on first and second leg. Instead they are clothed with hair, leaving bald stripes full length of each segment, one on femur, two on patella and tibia, and one on metatarsus and tarsus. The prolateral surface of the femur is quite bald, on the retrolateral surface

there is a bald stripe full length of the femur. There is a single row of trichobothria on the bald stripe of the metatarsus and two rows on the tarsus, but none elsewhere. Below, there are five or six long spines resembling bristles on the tibia and 2–2–4 short spines on the metatarsus. The third leg has two narrow dorsal bald stripes on the femur, one on the patella and a short oblique one on the tibia. The entire prolateral surface of patella, tibia and tarsus is covered with short spines evidently used in digging. A few similar spines are also on the retrolateral surface of the tibia and on the dorsal surface of metatarsus. Numerous spines are present on the ventral surface of tibia, metatarsus and tarsus. The fourth leg is less spinose than the third. We find what could be termed a femoral rastellum composed of short spines used in digging, at the end of the segment on its dorsal surface. There are also long thin spines on the ventral surface of the tibia, shorter spines below the metatarsus and numerous short spines below the tarsus close to its end. The color of the hair and spines on the fourth leg is purple. The trichobothria have the same arrangement on all legs. Claws 3. Upper claws strongly curved, with a few small teeth. Third claw smooth. Palp with numerous spines, its terminal joint with heavy scopula, its claw smooth. Spinnerets 4. Anteriors short, separated from each other by more than their diameter. Posteriors long, their third joint cone-shaped, about as long as second. First joint heaviest and almost as long as the other two together. Abdomen covered with purple hair above and brown hair below. Color in alcohol: Carapace yellow, head slightly darker. Chelicerae yellow with black rastellum. Legs yellow. Abdomen grey with an indefinite median purplish area and two median light spots. Below the entire spider is yellow.

One specimen from Mitchell, Indiana, caught in a field, in 1906. In my collection.

Brachybothrium shoemakeri n. sp.

Male. (Figures 3, 5, 6 and 11).

Total with chelicerae—14.5 mm. Carapace 5.950 long, 4.590 wide, strongly emarginate behind, smooth, with a few hairs along lateral margins. Head elevated. Thoracic groove deep, longitudinal. Eyes on a tubercle. Anterior row procurved, posterior recurved and slightly longer. Ratio of eyes AME : ALE : PME : PLE – 8 : 10 : 5.5 : 6. AME round, close together, their pupils separated from each other by the radius of the cornea. ALE appear to be almost round when viewed from the side, though the outline is somewhat irregular. They are close to the AME from which they are separated by half the radius of the latter. AME are still closer to PME than to each other. PME are almost contiguous with PLE. Laterals are also almost contiguous. AME are separated from the anterior margin of the carapace by their diameter, ALE by less than their radius. Chelicerae with a rather poorly developed rastellum consisting of a single row of spines situated on the edge of the basal joint from the middorsal point inward, all told eight or nine spines. Promargin with a row of 12 teeth, retromargin smooth. Scopula only on retromargin. The shape of the

chelicerae is peculiar and best understood from the figure. The lip is immobile, though clearly distinct from the sternum. It is convex transversely, rounded anteriorly and posteriorly, with a straight line across the middle. Behind lip two semicircular areas analogous to sigilla and probably corresponding to the real first pair. The three pairs of sigilla usually described as such are oval, evenly spaced, last pair more than their length from margin. Sternum egg-shaped, longer than wide, sparsely covered with erect black hair. Spinnerets 4, in a transverse line, posteriors to the outside and somewhat behind anteriors. Anteriors about as long as basal joint of posteriors, thinner and slightly more slender at base, separated from each other by more than their diameter at base (5 : 4). Posteriors long, three-jointed. Middle joint as long as basal, terminal longer and thinner. Posteriors separated at base by almost half their length. Legs 4123.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	5.100	2.125	3.485	4.420	2.550	17.680
II	4.675	2.125	2.975	4.165	2.550	16.490
III	4.165	2.040	2.720	4.250	2.975	16.150
IV	5.100	2.295	3.655	5.100	2.975	19.125

All tarsi slightly curved dorsally at base, very slightly scopulate, scopula divided by a median row of small bristles. Claws 3. Upper claws on all legs with 6 or 7 teeth in a single row. These teeth are not midventral in position, but begin on both claws at outer edge and forming a curve pass distally to the inner edge. Third claw smooth. Spines on legs numerous and heavy. On the first leg we find several large spines below on tibia and a number of spines and spine-like bristles on the prolateral surface of this joint. These spines have a peculiar interest attached to them, inasmuch as they are directed not forward as usual, but upward at an angle of more than 45°. On the first metatarsus there is but one heavy apical retrolateral spine. Trichobothria are, on all legs, in two converging rows on the tibiae, and in a single row on the metatarsi. There are no trichobothria elsewhere. Second tibia is less spinose than the first, but the second metatarsus has numerous spines. Third and fourth legs are heavily spinose, including even the patella. The femur of the palp is thin and long, the tibia shorter than the femur and twice as heavy and bears near its end on the outside about 20 bristles, the tip of which is bent at an angle forward. The bulb is provided with a conductor of an almost equal length with the embolus. The edge of the conductor appears distinctly serrated under high power.

Coxae of pedipalpi with parallel sides, longer than wide (23 : 14) with proapical angle distinctly drawn out. Palp inserted apically. Scopula long, reddish brown.

Color in alcohol: yellowish brown above and below. Abdomen greyish brown with a darker spot on back in front, another immediately behind the first and a third spot in the shape of a transverse segment in the middle. A peculiar feature of the spider is the presence of large black spines on these spots. There are over a dozen of such spines on the anterior spot, a transverse row of eight spines on the second spot

and a transverse row of six spines on the third spot. There are also some stiff bristles behind the last spot, but their arrangement is irregular. The spinnerets are lighter colored than the rest of the abdomen.

Immature Female.

Total with chelicerae 13.0 mm. Carapace 4.250 long, 3.060 wide. Legs 4132.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	2.720	1.360	1.615	1.700	1.190	8.585
II	2.295	1.360	1.360	1.445	1.020	7.480
III	2.210	1.190	1.445	1.615	1.190	7.650
IV	2.805	1.445	1.785	1.955	1.190	9.180
Palp	2.210	1.105	1.360	1.530		6.205

Palpal claw with two minute teeth. Legs and palpi with numerous spines of variable length and stoutness and of fairly regular disposition. On the first femur there is a dorsal row of bristles, the row slightly curving prolaterally toward end, thus leaving space for a mid-dorsal apical bristle. Less regularly arranged bristles are found on the ventral surface. Patella has 1–1 mid-dorsal bristles and several ventral bristles. Tibia has only 1–1 heavy ventral spines. Metatarsus has 1–1–1–1 prolateral and 1–1–2 retrolateral heavy spines and 1–1–1–2 ventral small spines, the third from base being a bristle. Second leg same as first, except metatarsus prolateral 1–1–1–2, retrolateral 1–1–1–2 and ventral 1–1–1–2. On the third leg the spines are shorter and heavier. Femur as in first leg, several dorsal spines on patella and tibia and at end of metatarsus. There are also 2–2–2 ventral spines on the tibia and 2–2–2 ventral spines on the metatarsus. Fourth leg much as third, but the spines are longer. Femur and patella of palp as in first leg, tibia has below a row of prolateral and a row of retrolateral spines which are not quite regularly arranged, terminal joint has similar, but somewhat more regularly arranged spines. The specimen has a young skin under the old one, and the ratio of the eyes cannot be given accurately.

Named in honor of Mr. Clarence R. Shoemaker of the U. S. National Museum, who collected the specimens, five males, an immature female and a young in different localities near Washington, D. C., on the Virginia bank of the Potomac River.

Family Theridiidae.

Genus **Ivesia,** new.

Type *Ivesia tennesseensis* n. sp.

This genus is closely allied to Theridionexus Petrunkevitch, from which it may be differentiated by the presence of only six eyes (anterior median eyes wanting), and by the wider separation of the posterior median eyes. Thoracic groove wanting. Promargin of chelicerae with only two teeth. Posterior tarsi with a comb of 11 serrated bristles and with two spurious claws on the retrolateral surface. Named in honor of Professor J. D. Ives.

Ivesia tennesseensis n. sp. (Figures 4, 7, 8, 9 and 10).

Male. Total with chelicerae 3.740 mm. Carapace 1.700 long, 1.530 wide, considerably narrowed in front, without thoracic groove, but with a deep depression in its place. Margins with very short, spinelike hair. Surface glabrous, with a few long hairs in front of thoracic depression and on eyegroup. Eyes six, all nocturnal, oval. Anterior median eyes wanting. Laterals contiguous, subequal in size, anteriors a shade larger. Posterior row procurved. PME more separated from each other than from PLE with which they are equal in size. Clypeus high, saddleshaped, i. e., convex transversely, concave in median line, extending far over the base of chelicerae. Chelicerae moderately long, gradually thinner toward fang, which is evenly curved. Margins oblique. Promargin with two teeth, retromargin smooth. Under high power one can discern 11 minute teeth or granules at the juncture of both margins. Scopula of promargin composed only of one row of eight hairs, that of the retromargin of one row of six hairs. Boss and stridulating ridges wanting. Fang with a bluntly serrated edge. Lip much wider than long, rebordered, transversely rectangular, articulated to maxillae near its end. Maxillae longer than wide at base, with strongly oblique truncature covered with a dense scopula. The serrula is black and clearly visible. Sternum convex, triangular, almost as wide in front as in middle, pointed between hind coxae which are far apart. The surface of the sternum is glabrous with a few scattered black long hairs. Legs 1423.

	Femur	Patella & Tibia	Metatarsus	Tarsus	Total
I	3.655	4.420	3.315	1.275	12.665
II	3.230	3.570	2.550	1.105	10.475
III	2.635	2.635	2.040	0.850	8.160
IV	3.400	3.910	2.820	1.105	11.235

All femora curved downward, especially those of the first and fourth pairs. Legs without spines. Hair rather long, especially on anterior legs. Claws long, situated on an onychium. Upper claws strongly bent (not curved), with a series of 7 or 8 teeth increasing in length distally. Third claw smooth. Fourth tarsi with a comb of 11 bristles. Trichobothria hard to distinguish because of injury in transportation, but presumably as in female. Abdomen egg-shaped, sparsely clothed with hair. Colulus present. Spinnerets of the typical kind. Palpi with long, thin, cylindrical femur, short and almost globular patella, short and stout tibia with an exceedingly short apical apophysis on the outside. It may be added here that the apophysis which I have once described in Theridionexus cavernicolus as belonging to the tibia, in reality belongs to the terminal joint as is the case with Ivesia. The mistake was made possible by the use of a comparatively poor instrument. Under a good binocular microscope the structure of the palp is much easier to follow. In Ivesia tennesseensis the terminal joint is quite complicated, with an enormous curved, trough-shaped, trifid apophysis at base on outside (in the specimen under consideration the cymbium is so turned on its axis that the apophysis appears to be on

the inside). Embolus very long, curved, black. Cymbium almost rectangular, smaller than bulb. Color in alcohol: yellow, abdomen grey. Legs and palpi darker than carapace. Bulb reddish brown. Below the legs are yellow. Abdomen grey with yellow spinnerets. Sternum, maxillae, lip and chelicerae dark yellow.

Female. Total with chelicerae 3.740 mm. Carapace 1.530 long, 1.360 wide. Legs 1423.

	Femur	Patella & Tibia	Metatarsus	Tarsus	Total
I	3.060	3.740	2.550	1.105	10.455
II	2.550	3.060	2.040	0.935	8.585
III	2.210	2.210	1.615	0.765	6.800
IV	3.060	3.145	2.125	0.935	9.265

Fourth leg with tarsal comb of 11 serrated bristles better visible than in male. No spines on legs. Upper claws of first and second leg similar, pectinate with 11 teeth, those of third and fourth leg slightly dissimilar inasmuch as the retroclaw has not as many teeth as the proclaw. There are no spurious claws on first and second tarsi, while on third and fourth there are two spurious claws on the retrolateral side. Claw of palp with 11 teeth. Trichobothria on all tibiae five in a single row. There is also a single, very long trichobothrium on all metatarsi beyond middle of joint. Tibia of palp with three trichobothria. Tracheal spiracle near spinnerets and the trachea divides immediately into four parallel stems. Colulus small, but well visible. Epigynum as figured, composed of two separate receptacles on a common field. Color as in male.

Several males and females collected by Professor J. D. Ives in the Indian Cave, about five miles northwest of New Market, Tennessee, about a quarter of a mile from the entrance, in absolute darkness.

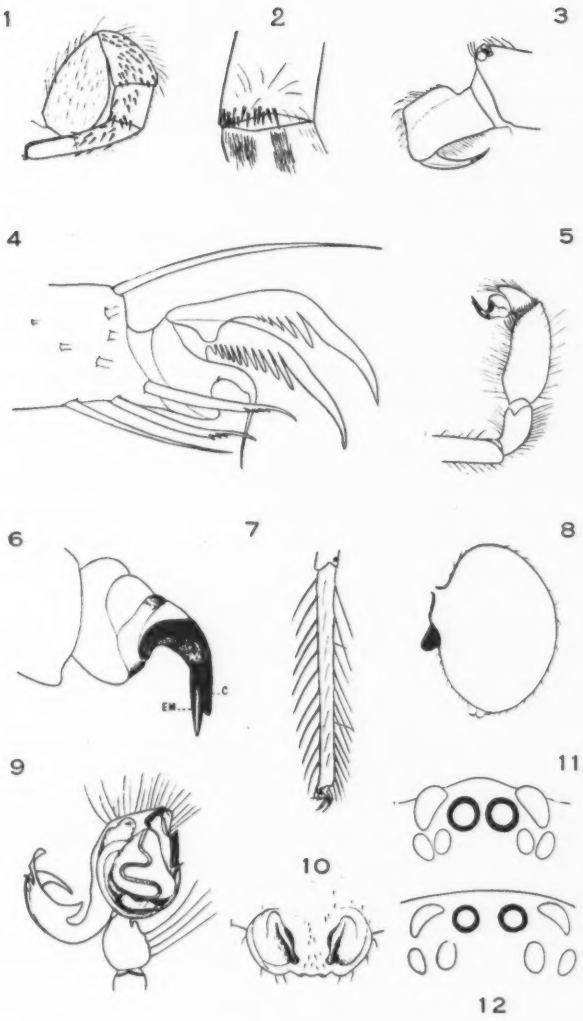
EXPLANATION OF PLATE XX.

Aptostichus flavipes n. sp. Female. 1—Third leg, outside view (prolateral), showing spines. 2—End of fourth femur and base of patella, dorsal view showing spines. 12—Eyegroup and clypeus.

Brachybothrium shoemakeri n. sp. Male. 3—Sideview of chelicera. 5—Palp showing relative proportion of femur and tibia and the spines at end of tibia. 6—Left bulb viewed from the outside (retrolateral) showing embolus and conductor. 11—Eyegroup and clypeus.

Ivesia tennesseensis n. g., s. sp. Female. 4—Claws at end of fourth tarsus, showing also the two spurions claws. 7—Fourth tarsus showing comb. 8—Sideview of abdomen, showing prominent epigynum. 10—Epigynum from above.

Male. 9—Palp showing tibia and terminal joint with immense apophysis. The embolus is black, thin and curved. Its end appears under the tip of the cymbium.



Alexander Petrunkevitch

THE GENUS DIKRANEURA AND ITS ALLIES IN NORTH AMERICA.

By E. D. Ball and D. M. DeLong.

A recent study of the species of the genus *Dikraneura* occurring in North America has brought out the fact that there are a number of additions and corrections that should be made to the list in the Van Duzee Catalog. It has also shown that there are three distinct groups of species included in our fauna. One of these differs so markedly in both structure and habits from the typical group that it has been generically separated in this paper.

D. variata Hardy, the type of the genus, has the third apical cell in the elytron long and rectangular. A group of species closely related to *variata* occurs in our fauna, while a second group has the third apical cell short, triangular, and with a pedicel of varying length. This second group bears the same relation to *Dikraneura* proper that *Typhlocyba* bears to *Erythroneura* and as in the two latter genera this character seems to be constant and correlated with a number of other characters which render the groups quite distinct.

Key to the Genera.

A. Third apical cell of elytra long and slender, usually nearly rectangular at the base, never petiolate.....Genus *Dikraneura* Hardy.
AA. Third apical cell of elytra short, broad at apex, triangular, petiolate.....Genus *Alconeura* n. gen.

Genus **Dikraneura** Hardy.

Dikraneura Hardy Trans. Tyneside Nat. Field Club I, p. 423, 1850.
Notus Fieber Verh. Zoo-Bot. Ges Wien XVI, p. 508, 1866.

Elytra without an appendix. Four longitudinal nervures running directly to the base of the apical cells without branching. No closed cells in the elytra before the apicals, four apical cells, the third usually long and slender and always nearly rectangular at the base. The fourth cell variable, the cross nervure sometimes indistinct. Under wings with a marginal vein and two closed cells at the apex, the first two nervures uniting to form the outer boundary of the first apical. Head conical, usually rectangular or even acutely angular in the female, more rounding in the male.

The two major groups set off below differ widely in habits. The members of the first group are all small slender leafhoppers with long closely folded elytra usually unicolorous, greenish-yellowish or pale, occasionally variably ornamented with red.

They are widely distributed inhabitants of damp meadows, while those of the second group are much more definitely ornamented and as far as known are tree or shrub inhabiting forms.

Van Duzee (1917) gives *Chloroneura* Walsh as a synonym of this genus, but it is a synonym of *Empoasca* Walsh instead. Walsh placed *abnormis* as his first species of *Chloroneura*, but his figures of the venation of the underwing and elytron, the characters on which he founded the genus, are those of *Empoasca*. In his description of *abnormis* he pointed out the variation from the characters of the genus.

Most authors have made use of color characters almost exclusively in separating the species, ignoring many good structural characters that might have been used to advantage and would have obviated much confusion of species and many errors of reference of specimens lacking the distinctive markings. In this study the size, the relative elongation of the vertex, the general form, the size, the shape, and relationships of the apical cells and the male genitalia, have all furnished relatively constant and valuable characters. In some groups certain color characters have been found to be constant and valuable and have been used.

KEY TO SPECIES OF DIKRANEURA.

A. Fourth apical cell long and slender, extending one-third its length below base of third. Species long, slender, usually unicolorous (or with occasional red striped varieties).
  B. Broad, unicolorous, milky white, female segment concavely rounded, margin embrowned, male plates with slender divergent apices.... 1. *mali* Prov.
  BB. Slender, greenish or yellowish, often with traces of red or white lines.
    C. Yellow, apex of head orange, no stripes, male plates ox-bowed. Female segment with large round central tooth.....2. *fieberi* Löw.
    CC. Greenish or pale, often striped with red, male plates, not ox-bowed, often narrow, attenuate.
      D. Size large, more than 4 mm. in length. Elytra long and narrow.. 3. *elongata* n. sp.
      DD. Smaller, not exceeding 3.5 mm. in length.
        E. Slender, vertex strongly produced, acute, at least three-fourths as long at middle as width between eyes at base.
          F. Small very narrow, female segment concavely rounded, center embrowned, lateral angles prominent, rounded.....4. *angustata*, n. sp.
          FF. More robust, female segment convexly rounded, not embrowned, lateral angles wanting.
            G. Greenish marked with yellow, male plates with narrow apices which are well rounded and blunt at tips.....5. *abnormis* Walsh.
            GG. Dull red in color, male plates with narrow pointed apices.....6. *rufula* Gill.
        EE. Normal shape, vertex obtusely angled only about half as long at middle as width between eyes at base..... 7. *carneola* Stal.

AA. Fourth apical cell shorter, extending but little if any below third. Species stouter or highly ornamented.
H. Third apical cell nearly rectangular at base.
I. Without a round black spot in the apical cell of elytra.
J. Short and stout (2.5 mm.) dull green to brown.
K. Pale green, vertex, pronotum and scutellum sprinkled with orange or dull red.....8. *kunzei* Gill.
KK. Dark sordid green to brown, a pale band between eyes on margin of vertex with a transverse brown line at its center.....9. *marginata* DeLong.
JJ. Pale in color white or yellowish, sometimes marked with red.
L. Pale yellow or white usually with two oblique red lines on each elytron and black coloring on cross nervures. Face normal.....10. *cruentata* Gill.
LL. Smaller, bright yellow marked with orange, female segment with posterior margin strongly produced, sharp pointed. Face very tumid....11. *sandersi*, n. sp.
II. White or pale yellow with a black spot in apical cell of elytra.
M. White, no red markings, black spot at base of cross vein of outer apical cell.....12. *mera* McAtee.
MM. Elytra white with red band, a black dot at base of inner apical cell.....13. *cockerelli* Gill.
HH. Third apical cell triangular, specimens pale, heavily spotted with red. 14. *maculata* Gill.

1. **Dikraneura mali** (Prov.)

(Plate XXI, Fig. 1; Plate XXII, Figs. 1, 1a, 1b.)

Erythroneura mali Prov. Pet. Faune Ent. Can. III, p. 298, 1890.
Dicraneura communis Gill. Proc. U. S. Nat. Mus. XX, p. 718, 1898.

Rather broad, uniform, sordid milky white, with a yellowish shade on vertex, margin of the pronotum and the scutellum, vertex right angled; second and third apical cells rather broad, almost parallel margined, their bases almost equal, fourth apical cell of same width but much longer, extending one-third its length below the cross nervures. Length, 3.5 mm.

Genitalia: Female last ventral segment more than twice as long as preceding. Posterior margin gradually produced from about half its length to a slightly bilobed portion, formed by a shallow concavity, occupying the median half of the segment. This portion heavily embrowned. Male valve short and contained in concavity of last ventral segment. Plates broad at base, abruptly, convexly rounded to narrow, divergent upturned apices.

Habitat: Examples have been examined from Colorado, Iowa and Wisconsin (Ball); Michigan, New York and Canada (U. S. N. M.); Connecticut, New York, Pennsylvania (DeLong); Ohio, Maine and Illinois (Osborn); and Gillette records it from Michigan and Illinois.

This is one of the most common species from the Rocky Mountains to the Atlantic and is easily recognized by its breadth and uniform milky white appearance. The enlarged male genitalia are strikingly distinct and will at once separate it from any other species.

2. **Dikraneura fieberi** (Löw.)

(Plate XXI, Fig. 2; Plate XXII, Figs. 3, 3a, 3b.)

Notus fieberi Löw in Then Kat. Osb. Cicada, p. 39, 1886.
Dikraneura fieberi Van Duzee Cat., p. 701, 1917 (for Amer. ref.)
Dikraneura flavipennis of Amer. Auth. (Not Zett or Europ Ref.).

Small, narrow, inconspicuous, pale yellow with orange mottling on apex of head, sometimes bright yellow; vertex variable, about right angled; second apical cell parallel margined, third apical widening towards apex, its base some distance in advance of the second, fourth cell extending half its length below the third. Length, 3 mm.

Genitalia: Female last ventral segment, sharply convexly incised either side of a broad, produced median lobe with apex broadly rounded or slightly incised. Male valve swollen, semi-lobular, plates long, slender, curved, widely separated at base, together forming an oxbow or resembling the appendages of the Forficulidae. A pair of black spines just before the apex meet each other.

Habitat: Examples have been examined from Utah, Wyoming, Colorado, Iowa, Wisconsin, Vermont, New Hampshire and District of Columbia, (Ball); Wisconsin, Ohio, Tennessee, Connecticut (DeLong); Kansas, Illinois, Louisiana (U. S. N. M.); Maine, New York and Indiana (Osborn). Gillette records it from Massachusetts and New Jersey. This common European species seems to be widely distributed from the Atlantic as far west at least as the Wasatch Mountains in Utah. It is a small yellow species and is quite distinct and easily recognized. The golden yellow form has been determined as *flavipennis* Zett., but all the examples from this continent examined by the writers have proved to be the above species. The striking genitalia will at once distinguish the male and the female of *flavipennis* should have an acute vertex.

3. **Dikraneura elongata** n. sp.

(Plate XXI, Fig. 3; Plate XXII, Figs. 4, 4a.)

Resembling *abnormis*, but larger and with more bluntly angled vertex. Length 4.5 mm.

Vertex about three-fourths as long as width between eyes. Elytra very long and narrow, greatly exceeding abdomen. Face yellowish, body dull green to milky white, a pair of orange yellow stripes extending from anterior margin of vertex to basal angles of scutellum. Elytra washed with orange yellow, outer claval vein milky white.

Genitalia: Female last ventral segment long, posterior margin roundingly produced, a slight emargination either side of central lobe and a median keel, from which a brownish line extends to base, gives the impression of a median incision.

Described from two females collected by the senior author at Santa Barbara, California, April 25, 1908.

4. **Dikraneura angustata** n. sp.

(Plate XXI, Fig. 4; Plate XXII, Figs. 5, 5a, 5b.)

Form and general appearance of *abnormis*, but smaller, very slender, and with distinct genital characters. Length, 3–3.25 mm.

Vertex strongly produced and angled, slightly wider between eyes than length at middle. Elytra long and narrow; venation as in *abnormis*.

Color: Vertex, pronotum and scutellum yellowish, elytra subhyaline, appearing bluish green, due to dark color of abdomen. Face and venter dull yellow.

Genitalia: Female last ventral segment slightly shorter than preceding, lateral angle produced, posterior margin broadly, concavely rounded, central half embrowned. Male valve broad, as long as preceding segment, posterior margin almost truncated. Plates broad at base, convexly rounded to narrow, upturned divergent apices.

Described from a series of twenty-five specimens from Memphis, Knoxville, and Clarksville, Tennessee, collected during June, July, August and September, 1915, and cited as *abnormis* by the junior author. It can be separated from *abnormis* by the broad emarginate segment of the female instead of the produced narrow segment, and the divergent tapering plates of the male.

It is probable that most of the references to *abnormis* from the Southern States will be found to belong to this species.

Specimens are also at hand from Dallas, Texas (Urbahns), and Clemson, S. C. (Ainslie), in Osborn collection; and Kansas (Lawson).

5. **Dikraneura abnormis** (Walsh.)

(Plate XXI, Fig. 5; Plate XXII, Figs. 8, 8a, 8b.)

Chloroneura abnormis Walsh (Prairie Farmer, Sept. 6, 1862, reprint Boston Soc. Nat. Hist. IX, p. 316, 64.

Very slender, pale green, washed with pale yellow on vertex, pronotum and scutellum, sometimes with a median and two lateral white lines with a pair of red stripes between on vertex and pronotum; elytra pale green fading to subhyaline posteriorly inclined to be smoky at the apex. Vertex acutely angled. Second and third apical cells extremely narrow and parallel margined, together scarcely as wide as the first, third apical with the base definitely beyond the second, fourth extended one-third its length before the cross nervures. Length, 3.5 mm.

Genitalia: Female last ventral segment almost twice as long as preceding. Lateral margins gradually convexly rounded from base to

form posterior margin which is slightly indented at apex. Male valve broad concavely rounded posteriorly. Plates broad at base, gradually narrowed to narrow, rounded apices.

Habitat: Specimens have been examined from Kansas, Missouri, Iowa, Illinois, and Ohio (Ball); Wisconsin, Pennsylvania, New York, Connecticut (DeLong); District of Columbia and Virginia, (U. S. N. M.). It is probable that the records for Texas, Georgia, and North Carolina belong with the preceding species. As now defined this species appears to be limited to the regions east of the Rocky Mountains. The extremely acute head and slender form will at once separate this and the preceding species from all others.

Var. **urbana** n. var.

Resembling typical *abnormis* in form and structure, but lacking the red stripes. Vertex, pronotum and scutellum pale yellow; elytra milky, subhyaline.

Described from four examples of both sexes, from Ames, Iowa. Walsh described *abnormis* from examples with definite red stripes. The majority of the examples of this species do not possess these markings and will fall into the above variety.

6. **Dikraneura rufula** Gill.

(Plate XXII, Figs. 2, 2a, 2b.)

Dikraneura abnormis var. *rufula* Gill. Proc. N. M. XX, p. 720, 1898.

Resembling the former in general form and appearance. Entire dorsal surface with a distinct reddish tint. Vertex and pronotum often paler, elytra spotted or washed with red to cross veins.

Genitalia: Female last ventral segment longer than preceding, posterior margin convexly, roundingly produced, slightly indented at middle. Male valve transverse, short, side margins rounded. Plates rather suddenly narrowed at two-thirds their length to form prolonged slender apices.

Habitat: Examples have been examined from California (Ball) and Gillette's material was from the same region. A study of the additional material indicates that this is a much larger species than *abnormis* and quite distinct structurally. It probably replaces that species in the California region.

7. **Dikraneura carneola** (Stal.)

(Plate XXI, Fig. 6; Plate XXII, Figs. 9, 9a, 9b.)

Typhlocyba carneola Stal. Stet. Ent. Zeit. XIX, p. 196, 1858.

Form and venation of *fieberi* nearly, stouter, soiled pale greenish above, face smoky, venter dark, a definite light median line on vertex

and anterior half of pronotum; disc of the vertex and pronotum either side this line and the nervures of the elytra before the cross nervures irrorate with red. Length, 3.5 mm.

Genitalia: Female last ventral segment longer than preceding, lateral angles rounded to posterior margin, which is broadly roundingly produced, often appearing slightly indented at middle. Male valve almost transverse, sides straight, plates broad at base, gradually sloping to narrow, slightly upturned apices.

Habitat: Specimens have been examined from British Columbia, Oregon, California, Santa Fe, Mexico, Utah, Idaho, and Colorado (Ball); Ontario and Minnesota (Lawson); Arizona and New Mexico (U. S. N. M.); South Dakota (Severin). Stal described it from Sitka and Gillette records it from Washington.

This is the most abundant and widely distributed species in the western region occurring from Alaska to California and East to New Mexico and Colorado. The smoky face and dark venter will serve to separate most specimens, the definite white line on the vertex is quite distinctive when present. The small triangular plates of the male will at once separate it from the other common meadow forms.

Var. *sitkana* nov. var. Pale green, vertex, scutellum and the margins of pronotum yellowish, sometimes a white median line on vertex, face smoky, venter dark. Described from a pair from Salt Lake and another pair from Logan, Utah, collected by the senior author.

8. **Dikraneura kunzei** Gill.

(Plate XXI, Fig. 13; Plate XXII, Figs. 7, 7a, 7b.)

Dikraneura kunzei Gill. Proc. U. S. Nat. Mus. XX, p. 721, 1898.

Small, green, with the vertex, margins of pronotum and the scutellum pale creamy, sometimes mottled with red; vertex obtusely angulate, apex rounding. First apical cell narrow, second apical very narrow, parallel margined, fourth apical over twice longer than wide, its basal cross nervure in line with the other cross nervures. Length, 2–2.5 mm.

Genitalia: Female last ventral segment twice length of preceding, lateral angles rounded to posterior margin which is gradually produced to a median blunt tooth at apex. Male valve contained within and almost concealed by last ventral segment. Plates rather broad at base, gradually narrowed to long, narrow, attenuate, upturned tips.

This neat and distinct species was described from Tuscon, Arizona, and the National Museum has material from Victoria, Texas, labelled "defoliating huisache" (Mitchell). It is probably limited to the southwestern region.

9. **Dikraneura marginata** DeLong.

(Plate XXI, Fig. 12; Plate XXII, Figs. 6, 6a, 6b.)

Dikraneura marginata DeLong. Journ. N. Y. Ent. Soc., Vol. XXXII, p. 68, 1924.

Size and form of *D. kunzei*, but without the red markings, and with distinct genitalia. Length, 2–2.5 mm.

Vertex produced, slightly wider between eyes than length at middle. Elytra with outer cell lanceolate, venation differing from *kunzei* by a straight basal cross vein on the inner apical cell which is more posterior than in *kunzei*.

Color: Vertex dull yellow, tinged with brown, median impressed line and a line just above margin and parallel with it, brownish. Margin below this line pale yellow with a narrow brown line slightly below middle, not extending to eyes. Face below brown, without traces of arcs. Pronotum with anterior third dull yellowish, disc and posterior margin sordid green. Scutellum dark green, apical third paler. Elytra sordid green tinged with yellow, apical portion paler, venation yellowish. Tergun black, venter dark brown marked with yellow.

Genitalia: Female, last ventral segment longer than preceding, posterior margin gradually produced and somewhat convexly rounded. Male valve short, broadly rounded, almost contained within the concavity of last ventral segment. Plates three times as long as width at base, gradually narrowed and produced into long attenuated apices.

Habitat: Specimens are at hand from Miami, Florida, (DeLong), and a series collected by Prof. J. G. Sanders at Panama City, Gamboa, Cristobal, and Alhajuela, Canal Zone, January to March, 1921.

10. **Dikraneura cruentata** Gill.

(Plate XXI, Fig. 9; Plate XXIII, Figs. 10, 10a, 19b.)

Dicraneura cruentata Gill. Proc. U. S. Nat. Mus. XX, p. 717, 1898.

Small, slender, vertex conical, slightly acute with the apex rounded, pale creamy, with sanguineous markings as follows: A median stripe on vertex, two stripes on pronotum arising just inside the eyes, the scutellum, and a pair of narrow oblique stripes on each elytron. The first arises at the base of the clavus next the suture and extends in nearly to the inner margin just before the middle of the clavus. The second arises on the first sector of the corium just before the end of the first stripe and extends along the sector to just before the cross vein. The first apical cell of elytra is very broad, the second and third about equal and the fourth small and triangular. Length, 2.75 mm.

Genitalia: Female, last ventral segment one-half longer than preceding, posterior margin rather strongly produced from lateral angles to a broad, median tooth. Male valve short, posterior margin slightly convexly rounded; plates broad at base convexly and rather abruptly constricted at about two-thirds their length to narrow appressed apices which are slightly upturned.

Habitat: Specimens have been examined from California, Colorado, British Columbia, Kansas, (Ball); Tennessee, (DeLong); Ohio, Maine, (Osborn); New York and District of Columbia (U. S. N. M.); and McAtee records it from Maryland and Virginia.

Var. *lavata* McA. Entirely pale, creamy or with slightly smoky indications on the sectors near the cross-veins.

Var. *rubricata* McA. Scutellum entirely red, red markings and smoky band broader than usual.

11. **Dikraneura sandersi** n. sp.

(Plate XXI, Fig. 10; Plate XXIII, Figs. 12, 12a, 12b.)

A small yellow species superficially resembling *fieberi*, but closely related to *marginata*. Length, 2.5 mm.

Vertex bluntly produced, one-third wider between eyes than length at middle. Pronotum roundingly produced from near its base. Face very tumid. Venation as in *kunzei*.

Color bright yellow to orange. Vertex, pronotum and scutellum often washed with orange. Elytra yellowish subhyaline, in well marked specimens with a minute black spot on inner basal angle of inner apical cell.

Genitalia: Female last ventral segment long, posterior margin produced from about its middle either side to form a sharp pointed margin. Male valve roundingly produced, plates rather long and narrow, gradually tapering to narrow apices.

Described from a series of nine female and five male specimens collected by Prof. J. G. Sanders at Panama City, Canal Zone, January 31 and March 2, 1921. The bright yellow color and distinct female genitalia will readily distinguish it from other related species.

12. **Dikraneura mera** McAtee.

(Plate XXI, Figs. 11; Plate XXIII, Fig. 11, 11a.)

Dikraneura mera McAtee, Proc. Ent. Soc. Wash., Vol. 26, p. 76, 1924.

Resembling *cruentata* in form, color, and general appearance, but with a black spot on base of outer apical cell. Length, 3 mm.

Vertex well produced but bluntly angled, almost as long at middle as width between eyes at base.

Color milky white, eyes dark, clavus, tip of ovipositor and small spot on inner angle of outer apical cell black.

Genitalia: Female, last ventral segment longer than preceding, posterior margin roundingly produced, slightly keeled at middle, lateral angles wanting.

Known at present only from a female Holotype in the collection of W. L. McAtee, taken at Beltsville, Md., June 23, 1918.

13. **Dikraneura cockerellii** Gill.

(Plate XXI, Fig. 7; Plate XXIII, Figs. 13, 13a, 13b.)

Dikraneura cockerellii Gill. Psyche VII, Supp. p. 14, 1896.

Pale straw, the elytra white with an irregular slightly oblique red band across the anterior third, a definite round black dot in the basal angle of the first apical cell and sometimes smoky margins to the outer cross nervures. Vertex acutely angled, the first apical cell extremely broad at the base, the first apical nervure arising as a continuation of the second sector, then curving around the black dot to its normal position, the third apical is narrow and almost parallel margined, the fourth slightly wider but shorter, the cross nervure arising just below the base of the third apical. Length, 3 mm.

Genitalia: Female, last ventral segment twice as long as preceding segment, lateral angles prominent posterior margin, deeply broadly excavated to a slight notch at middle. Male valve very short, slightly concave or transverse. Plates gradually narrowed from base to rather narrow but blunt apices.

Habitat: Specimens have been examined from Los Angeles, California, St. George in Southwestern Utah (Ball); Los Cruces, New Mexico (U. S. N. M.); and McAtee reports it from Arizona. Specimens in Sanders collection are from Phoenix, Arizona (Cockerell) "on grape."

This is a strikingly distinct but very puzzling species; superficially it resembles an *Erythroneura*, while in some of its structural characters it has affinities with *Alconeura*. It is apparently confined to the Southwestern region. Professor Cockerell reported the New Mexico examples as abundant on grapes.

14. **Dikraneura maculata** Gill.

(Plate XXI, Fig. 8; Plate XXIII, Figs. 16, 16a.)

Dikraneura maculata Gill. Proc. U. S. Nat. Mus. XX, p. 716, 1898.

Slender, pale yellow, heavily spotted with red, omitting a light band before the eyes, an oval spot on the anterior disc and the posterior margin of the pronotum. Elytra irrorate with minute red points which are more or less aggregated into larger spots in a definite pattern. A dark spot on face. Vertex rectangular, the apex acute. First and second apical cells large, the third and fourth smaller, triangular. Length, 3 mm.

Genitalia: Female last ventral segment twice as long as preceding, posterior roundingly produced from near base.

The unique type of this species bears no locality or other label. Gillette states that it was sent from the Illinois State Laboratory of Natural History, so the general inference has been

that it was from Illinois. Mr. T. H. Frison, the present curator, informs us that there are no specimens of the species in the Illinois collection. In the writers' experience specimens sent out from the Illinois collection without locality labels usually proved to be from the Summers material taken in northern South America. The striking color pattern is also characteristic of tropical forms. There are two examples of this species in the National Museum Collection from Louisiana (C. F. Baker) and McAtee lists it from North Carolina and Maryland, so that it now can be recorded as occurring along the Atlantic and Gulf coast region of the United States.

Genus **Alconeura** n. gen.

Resembling *Dikraneura*, underwing with marginal nervure and two closed cells at apex; elytra with four apical cells, the third one always triangular and pedicellate, due to the union of the second and third nervures for some distance at the base, the fourth cell distinct but irregular in shape; small, robust, usually highly ornamented leafhoppers.

Type of Genus *Alconeura rotundata* n. sp.

KEY TO THE SPECIES OF *Alconeura*.

A. Vertex short, bluntly angular, extending but little before the eyes; species usually definitely lined or spotted.
  B. First apical cell very broad, the first apical nervure almost in line with the second sector, a black dot in the inner basal angle of the first apical cell.
    C. First apical nervure curved around the black dot, species red with pale lines.....1. *quadrivittata* Gill.
    CC. First apical nervure straight arising on a line with second sector, species pale with red lines.....2. *rotundata* n. sp.
  BB. First apical cell normal, the first apical nervure arising midway between the first and second sectors. The black dot located on the nervure or in the second cell just before the middle.....3. *unipuncta* Gill.
AA. Vertex long, acute, one-half its length before the eyes, species small.
    D. Vertex longer than basal width between eyes; vertex, pronotum and scutellum bright red.....4. *tricolor* Van D.
    DD. Width of vertex between eyes greater than length; color of vertex, pronotum and scutellum green.....5. *planata* n. sp.

1. **Alconeura 4-vittata** (Gill.)

(Plate XXI, Fig. 15; Plate XXIII, Figs. 19, 19a.)

Dikraneura 4-vittata Gill. Proc. U. S. Nat. Mus. XX, p. 723, 1898.

Broad with an obtusely angled, thick margined vertex, tawny red to just before the apical cells. The anterior margin and a median stripe on vertex white, three narrow stripes and the lateral margins of the pronotum white. Elytra pale, all the clavus except the margin, an interrupted stripe on the corium next the suture and an oblique dash near the middle tawny. Nervures and cross-veins on apical third thickened, pale yellow with smoky margins. A large black dot in the angle of the first apical cell. First apical broad, its base oblique, first

apical nervure arising from apex of second sector and curving around the black dot. Third apical small, triangular, almost oval, with a short pedicel, fourth apical semi-circular. Length, 2.5 mm.

Genitalia: Male valve apparently concealed, plates rather long, gradually tapering to acute tips, apparently with side margins folded upward.

Known only from the unique male type in the National Museum labeled L. I. Bah. 4–1–1879, Swartz. Dr. Swartz states that this insect was taken on Long Island, Bahamas. This island is one of the most southern in the group, its southern extremity extending well below the tropic of cancer and is directly east of Havana, Cuba. This species is undoubtedly West Indian and semi-tropical in its affinities, and should not be listed as from the United States.

2. **Alconeura rotundata** n. sp.

(Plate XXI, Fig. 14; Plate XXIII, Figs. 14, 14a, 14b.)

Broad, creamy yellow, with two irregular pale red stripes on the vertex and four on the pronotum. Elytra pale creamy, with traces of two oblique orange stripes, a black dot in the inner angle of the first apical cell and smoky margins to the costal nervures. Vertex obtusely angular, apex rounding, margin very thick, pronotum broader than head, elytra moderately long, the first apical cell very broad with the black dot in its inner basal angle, the first apical nervure straight and arising almost directly from second sector, third apical cell triangular with a definite pedicel, fourth apical cell large semi-circular, the bounding nervures smoky margined. Length, 3 mm.

Genitalia: Female, last ventral segment longer than preceding, lateral angles rounded then gradually produced to form a broad, produced median tooth. Male valve broadly convexly rounded. Plates with posterior portion folded and turned upward so that they appear to gradually slope to pointed apices.

Described from three females and one male from Ames, Iowa. Taken by the senior author August 5, 1895 on *Amorpha fruticosa*, and one male from Onaga, Kansas, July 9, 1898 (Crevecoeur), and five specimens from Ames, Iowa, in collection of Prof. Herbert Osborn. This is the stoutest species in the genus. It is much broader than *unipuncta*, which it otherwise resembles.

3. **Alconeura unipuncta** (Gill.)

(Plate XXI, Fig. 16; Plate XXIII, Figs. 15, 15a, 15b.)

Dikraneura unipuncta Gill. Proc. U. S. Nat. Mus. XX, p. 718, 1898.

Slender with a roundingly right angled vertex, pale milky with traces of pale red stripes on vertex and pronotum, traces of three oblique

pale yellow or brown stripes on the elytra, the one on clavus obliquely interrupted just back of the middle. Elytra subhyaline with the apical nervures and cross-nervures distinct, milky with smoky margins, apex broadly smoky, the black dot in the second cell touching the first nervure nearly half way from cross nervure to apex of elytra, first apical nervure arising midway between first and second sector. Third apical cell pedicellate, its margins rounding, fourth apical broader than its length on costa. Length, 3 mm.

Genitalia: Female, last ventral segment long, posterior margin produced, slightly indented either side of a broad, produced blunt pointed median tooth. Male valve apparently concealed; plates broad at base, narrowed and inner margins convexly rounded at half their length to form narrow divergent apices.

Habitat: Specimens have been examined from Grant's Pass, Oregon; San Francisco, Sacramento, and Pasadena, California (Ball); Ash Creek, Arizona; Utica, Mississippi; Alabama and Biscayne Bay, Florida, (U. S. N. M.); Miami, Florida, (DeLong). This species can be instantly separated from all others in the genus by its slender form and the location of the black dot.

Var. *nudata* n. var. Pale creamy, the elytra milky subhyaline, the cross nervures distinct, slightly smoky margined. Black dot prominent. Described from five examples from Pasadena and San Francisco, California. Collected by the senior author.

Var. *dorsalis* DeLong.

Dikraneura unipuncta dorsalis DeLong. Jl. N. Y. Ent. Soc. 32, p. 67, 1924.

Disc of vertex and pronotum, scutellum and claval areas of elytra covered with a broad longitudinal brownish band which is bordered by a white band extending along the margins of vertex from apex across margins of pronotum on to elytra at base and along claval suture half way to apex. Remainder of clavus brownish. Apical cross-veins pale, fuscous margined.

Very abundant in Florida everglade hammocks on *Trima floridana*.

4. **Alconeura tricolor** (Van Duzee).

(Plate XXI, Fig. 18; Plate XXIII, Figs. 17, 17a, 17b.)

Dikraneura tricolor Van Duzee. Trans. San Diego, Soc. Nat. Hist. II, p. 56, 1914.

Vertex strongly produced longer at middle than width between eyes. Black, upper portion of face, vertex, pronotum and scutellum

bright red, a pale median line crossing vertex and pronotum. Elytra golden green, costal margin tinged with red. Length, 2.5–3 mm.

Genitalia: Female last ventral segment longer than preceding, posterior margin sloping from lateral angles to a rounded median tooth which appears incised at middle. Male valve apparently concealed. Plates rather short, gradually narrowed to slender apices.

A distinct and beautiful little species known only from California and New Mexico. The bright red color of the vertex and pronotum will easily distinguish this species.

5. **Alconeura planata** n. sp.

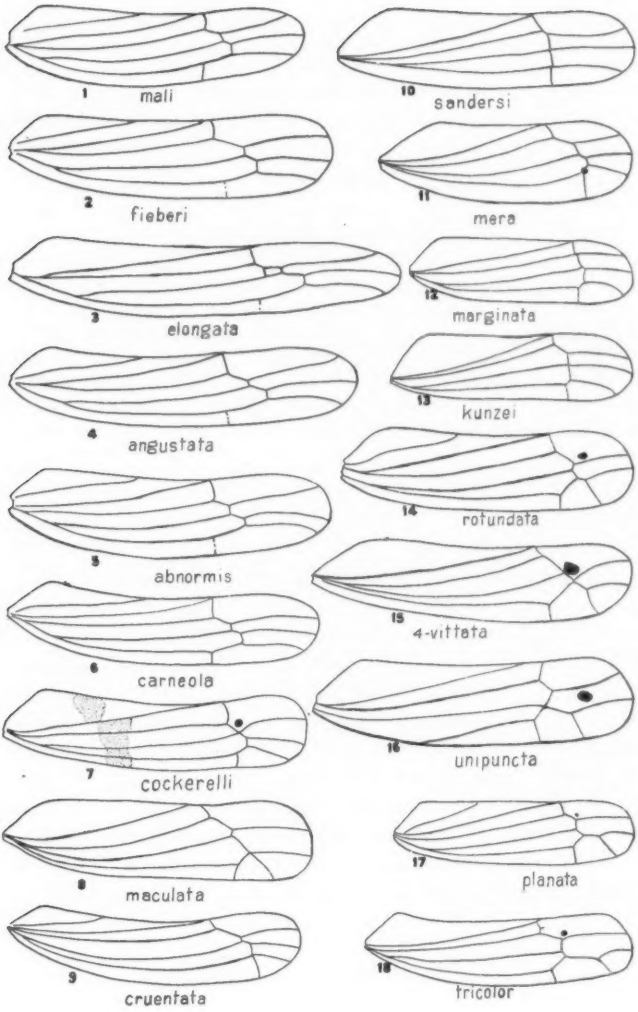
(Plate XXI, Fig. 17; Plate XXIII, Figs. 18, 18a, 18b.)

A very small stout greenish species superficially resembling *D. kunzei*, but with a black dot and a petiolate third apical. Vertex acutely angulate, twice as long as the eyes, width between eyes greater than length at middle. Pronotum broader than head, elytra broad and short. First apical with the black dot in the inner basal angle, the nervure straight and arising half way between the sectors. Third apical long, triangular, petiolate. Fourth apical very broad and short against costa.

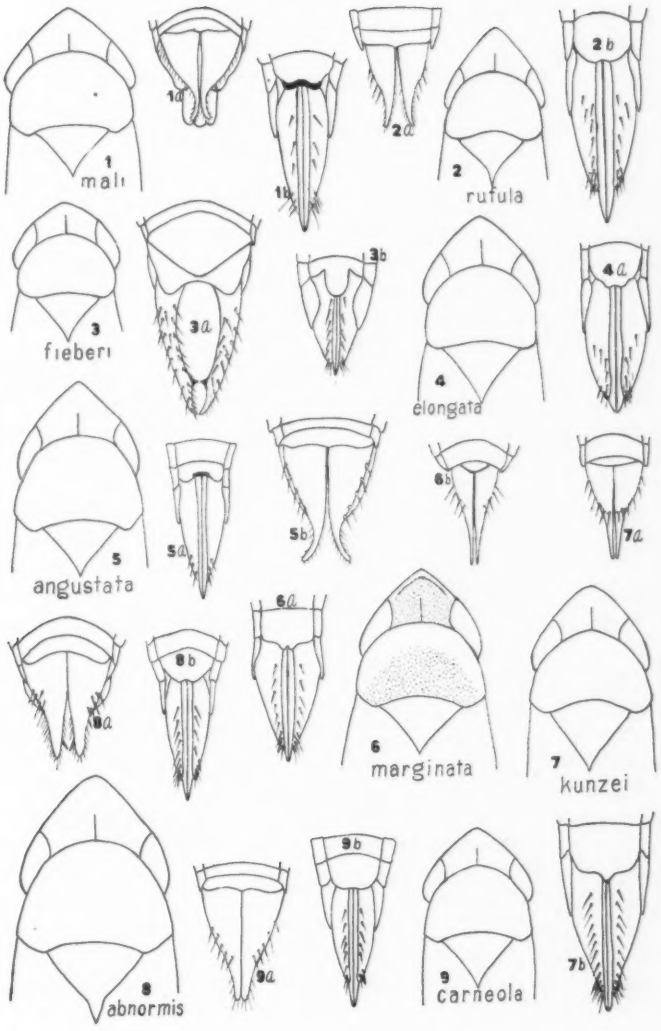
Color, green; vertex, scutellum and margins of pronotum pale yellow, a round black dot on first apical and sometimes a narrow light line on vertex and pronotum. Length, 2.5 mm.

Genitalia: Female, last ventral segment as long as preceding, lateral angles prominently rounded. Posterior margin concavely excavated either side of a produced median tooth about one-third the width of segment. Male valve convex posteriorly, exposed by concavity of preceding segment. Male plates rather long, broad at base, gradually narrowed to rather long, narrow apices.

Described from eight examples taken by the senior author at Helper and Soldiers Summit, Utah, August 13, 1906. A remarkably distinct little species from the Wasatch Mountains.



Ball and DeLong



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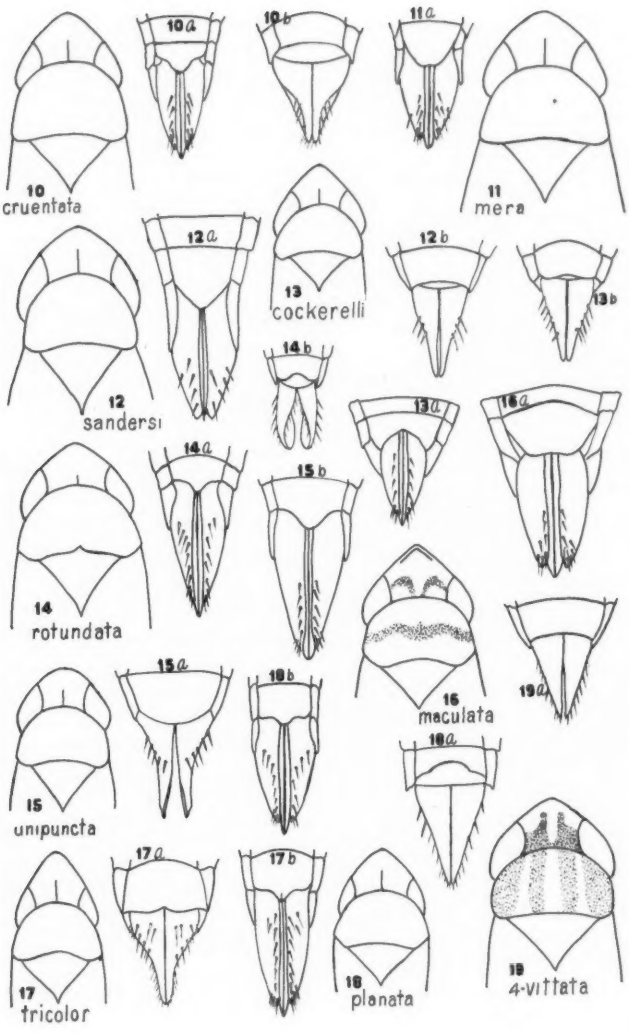

Ball and DeLong

STUDIES ON THE CRANE-FLIES OF MEXICO. PART I.

(Order Diptera, Superfamily Tipuloidea).

CHARLES P. ALEXANDER
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The crane-flies discussed at this time were included in very large and important collections made in various parts of Mexico by Dr. Alfons Dampf, Professor of Applied Zoology and State Entomologist. Our knowledge of the crane-flies of this great republic had hitherto been restricted to the relatively few species recorded by Osten Sacken and Williston in the "Biologia Centrali-Americana," together with a few scattered descriptions by the writer. This fragmentary knowledge has been vastly added to through the critical and systematic collecting methods employed by Dr. Dampf. In the present installment a number of new species are described from various localities in the vicinity of Mexico City. The habitats from which the various collections were made will be discussed in detail in later papers by Dr. Dampf, those employed at this time being included in the following *Mexican Biocœnosis* (M. B.) and *Mexican Fauna* (M. F.) numbers as adopted by the collector:

Desierto de los leones: A wild forested region some 25–30 kms. southwest of Mexico City, situated in the mountains at an altitude of 3,000 meters and over. The characteristic trees are *Pinus montezumæ*, *P. leiophylla*, *Abies religiosa*, *Quercus*, spp., and others, together with a dense undergrowth of many flowering shrubs and weeds. M. B. 73 is a very deep shadowy ravine (Barranca de la mina vieja, Rio Tapazulco de los Morales, 3010–3080 meters) in the *Abies religiosa* region, with a luxuriant growth of trees, shrubs and weeds. The very inconspicuous rivulet seeks its way through big stones, blocks and overhanging rocks. M. B. Nos. 25, 67, 73, 114, etc.; M. F. No. 66.

Chapingo: The new site of the Escuela Nacional de Agricultura, situated nearly 30 kms. east of Mexico City, lying

*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College.

in the plain of the valley of Mexico between the Lago Texcoco and the mountain chain called Tlaloc. M. B. Nos. 29, 35, 44, 47, etc.; M. F. No. 291.

Mt. Tlaloc: A mountain group lying northeast of Mexico City, belonging to the Popocatepetl-Iztaccihuatl chain. M. B. No. 67 is from the *Abies religiosa* region, altitude 2800–3200 meters, deep rocky barrancas with dead trees, dense forest intermixed with brush. Several of the novelties were included under this number, the specimens having been swept from the *Abies* branches. M. B. Nos. 63, 63a, are from the *Pinus* region, altitude 3000–3600 meters. M. B. No. 64 is from the summit at approximately 4000 meters, in treeless situations, with grass and creeping *Cupressus* between the rocks.

Peñon viejo or *Peñon marquez:* An old volcano half-way between Mexico City and Chapingo, situated on the southern border of Lago Texcoco. The specimens were collected by sweeping the vegetation in a deep muddy trench.

The writer wishes to express his thanks and appreciation to Dr. Dampf for the privilege of collaborating in this important investigation. Through the kindness of the collector, the types of the novelties are retained in the writer's collection.

Dicranomyia Stephens.

Dicranomyia praepostera sp. n.

General coloration fawn-yellow; head gray above; wings tinged with pale yellow, the costal region and vein Cu_1 seamed with darker; male hypopygium very complicated in structure.

Male. Length, 5.5–6 mm.; wing, 8.5–9 mm.

Rostrum obscure ochreous-yellow, moderately elongate; palpi short, dark brown. Antennae with the basal segment obscure brownish yellow, the apex and remaining segments brown; flagellar segments oval, with short verticils. Head gray above, the frons, occiput and ventral portions more yellowish.

Thorax uniformly fawn-yellow, the median area of the praescutum a little more suffused but without distinct darker markings; scutellum and postnotum sparsely pruinose. Pleura reddish fawn-color, sparsely pruinose. Halteres infuscated, the base of the stem narrowly yellowish. Legs with the coxæ and trochanters light yellow; femora obscure yellow, the tips broadly dark brown; tibiæ brownish yellow, the tips narrowly and indistinctly infuscated; tarsi gradually passing into dark brown. Wings (Fig. 1) tinged with pale yellow, the costal region darker, this color broadening out distally to include the outer radial cells; a conspicuous darker brown seam along vein Cu_1 and *m-cu;* brown seams at arculus, Sc_2, tip of Sc_1 and origin of *Rs;* a large oval spot at fork of *Rs;*

stigma darker at the ends, the center somewhat paler; cord and outer end of cell *1st* M_2 very narrowly seamed with brown. Venation: Sc_1 ending just beyond the origin of *Rs*, Sc_2 very far from its tip, lying about mid-distance between arculus and the origin of *Rs; m-cu* some distance before the fork of *M*.

Abdomen light brown, the genitalia passing into reddish brown; basal sternites pale yellow. Male hypopygium (Fig. 13) very large and complicated in structure. Ninth tergite (t) with a deep V-shaped notch, the lateral lobes obtusely rounded, the margins of the notch with delicate setæ. Basistyle (b) relatively small and simple. Ventral dististyle (v) very complicated, consisting of a kidney-shaped fleshy lobe provided with relatively short retrorse setæ; basal mesal portion produced into a complicated blade that bears the short bispinous rostrum. Dorsal dististyle a powerful, flattened, sickle-shaped blade that is expanded and truncate at tip. Gonapophyses (g) small, broad, the mesal apical angle provided with a short, erect lobe, the extreme tip of which is feebly decurved.

Holotype, ♂, Mt. Tlaloc, region of *Abies religiosa*, altitude 2800–3200 meters, June 15, 1924 (A. M. Dampf); M. B. No. 67. *Paratopotype*, ♂.

Dicranomyia praepostera is a very distinct species with no very close described relatives.

Dicranomyia ravida sp. n.

General coloration light gray, the praescutum striped with darker; antennae black throughout; wings subhyaline, the stigma faintly darker; *Sc* short; cell *1st* M_2 closed; male hypopygium with the spines of the rostrum unequal, curved.

Male. Length, 4.5–5 mm.; wing, 6–6.8 mm.

Female. Length about 5.8 mm.; wing about 6.8 mm.

Rostrum and palpi dark brown. Antennae black, the basal segment pruinose; flagellar segments short-oval. Head brownish gray, clearer gray in front.

Pronotum gray, darker medially. Mesonotum yellowish gray, clearer gray laterally, the praescutum with a conspicuous brown median stripe and smaller, less distinct lateral stripes; scutal lobes extensively infuscated; postnotum gray, darker laterally behind. Pleura light gray pruinose. Halteres pale, the knobs weakly infuscated. Legs long and slender, the coxæ reddish brown, the fore and middle coxæ darker and more or less pruinose basally; trochanters brownish yellow; remainder of legs dark brown, the bases of the femora brightened. Wings subhyaline, the stigma faintly indicated; veins dark brown. Venation (Fig. 2): *Sc* short, Sc_1 ending about its length before the origin of *Rs; Rs* a trifle longer than the basal deflection of R_{4+5}; *m-cu* at or immediately before the fork of *M*.

Abdomen dark brownish gray, the hypopygium conspicuously brownish yellow. Male hypopygium (Fig. 14) with the caudal margin of the ninth tergite (t) with a broad U-shaped notch, the lateral lobes low

and obtuse, provided with numerous setæ. Basistyles (b) relatively small, only sparsely setiferous, the mesal lobe large and conspicuous, setiferous. Ventral dististyle (v) larger than the basistyle, with conspicuous setæ, the rostrum long, curved gently to the tip, near two-thirds the length bearing the usual two spines, these of generally similar shape, but the more basal one about one-fourth shorter than the other, both gently curved basad. Dorsal dististyle relatively slender, angularly arcuated to the long acute point. Gonapophyses (g) with the mesal apical lobe curved gently laterad.

Holotype, ♂, Chapingo, February 25, 1924 (A. M. Dampf); M. B. 29. *Allotopotype*, ♀, March 1, 1924. *Paratopotypes*, 3 ♂ ♂, March 5, 1924, M. B. 35; 3 ♂ ♂, March 31, 1924, M. B. 44; ♂, April 30, 1924, M. B. 47. *Paratype*, ♂, Mexico, D. F., November 8, 1923 (A. M. Dampf).

Dicranomyia tricornis sp. n.

General coloration yellowish brown, the praescutum somewhat brighter with three conspicuous brownish black stripes; male hypopygium with the rostrum bearing three powerful straight spines.

Male. Length, 5.6–6 mm.; wing, 6.8–7.6 mm.

Female. Length about 5 mm.; wing, 7 mm.

Rostrum and frons obscure yellow, the palpi brownish black. Antennae brownish black throughout; basal flagellar segments short, the outer ones passing into oval, clothed with a delicate erect pale pubescence. Head grayish brown, the vertex between the eyes darker.

Pronotum brownish black medially, passing into obscure yellow laterally. Mesonotal praescutum obscure orange-yellow with three conspicuous brownish black stripes, the median one broader and more conspicuous; scutellum and postnotum gray pruinose. Pleura brown, sparsely covered with a yellowish pollen, more pruinose behind. Halteres relatively short, brown, the base of the stem indistinctly brighter. Legs with the coxæ brown, the fore coxæ darker; trochanters obscure yellow; legs relatively long and slender; femora pale brown, brighter basally, with a vague darker ring immediately before the tips; tibiæ and basitarsi pale brown, their tips narrowly darkened; remainder of tarsi dark brown. Wings (Fig. 3) rather strongly tinged with brown, the stigma scarcely indicated; veins dark brown. Venation: *Sc* short, Sc_1 ending opposite the origin of *Rs*, Sc_1 a little shorter than *m-cu*; *Rs* relatively long, feebly angulated at origin; *m-cu* at the fork of *M*.

Abdominal tergites dark brown, indistinctly variegated with paler; basal sternites yellowish, the more distal sternites yellowish basally; hypopygium obscure yellowish brown. Male hypopygium (Fig. 15) with the ninth tergite (t) broad, the caudal margin with a very shallow emargination, on either side of the broad median space with a dense patch of setæ. Basistyle with the mesal lobe conspicuously setiferous. Ventral dististyle (v) fleshy, the rostrum large, semichitinized, and

with a row of three closely approximated spines of subequal size, placed on the side of the rostrum not far beyond its base; face of style at base of rostrum further produced into a small fleshy lobe that is tufted with a few strong setæ. Dorsal dististyle (d) a powerful flattened blade, widest near midlength, the apex drawn out into a long acute point. Gonapophyses (g) with the caudal mesal angle relatively slender, curved.

Holotype, ♂, Mexico, D. F., January 30, 1924 (A. M. Dampf). *Allotopotype*, ♀, March 7, 1924. *Paratypes*, 1 ♂, Peñon viejo, May 11, 1924, M. B. 50; Peñon marquez, 1 ♂, March 3, 1924, M. B. 34; 1 ♂, March 5, 1924, M. B. 37.

Dicranomyia tricornis is distinguished from the other regional species of the genus by the presence of three spines on the rostriform appendage of the male hypopygium.

Dicranomyia filicauda sp. n.

General coloration gray, the rostrum yellow; pronotum and mesonotal praescutum with dark brown stripes; halteres elongate; wings faintly tinged with brown, the stigma slightly darker; Sc_1 long; male hypopygium very complex in structure, the tergal region with two long, filiform lobes.

Male. Length about 6.5 mm.; wing, 8.5–8.6 mm.

Rostrum light yellow; palpi dark brown. Antennæ dark brown; flagellar segments oval. Head dark gray, the front and orbits paler.

Pronotum gray, dark brown medially, the sides passing into buffy. Mesonotal praescutum gray, the humeral regions broadly ochreous, the dorsum with three conspicuous dark brown stripes, the median stripe broad and conspicuous, the lateral stripes narrow and subobsolete; centers of scutal lobes dark, the median area pale; scutellum dark, indistinctly pale medially and more distinctly so caudally; postnotal mediotergite dark brown. Pleura pale, yellowish pollinose, with a short and narrow pale brown longitudinal stripe extending across the suture between the anepisternum and the sternopleurite. Halteres long and slender, infuscated, the extreme bases pale. Legs with the coxæ pale, the fore coxæ slightly infuscated; trochanters obscure yellow; femora brown, their bases paler; tips of femora indistinctly pale; remainder of legs passing into dark brown. Wings (Fig. 4) with a faint brown tinge, the oval stigma pale brown; veins dark brown. Venation: Sc_1 ending opposite the origin of *Rs*, Sc_2 some distance from the tip of Sc_1, the latter alone about two-thirds *Rs;* cell *1st* M_2 closed, *m* being about two-thirds the outer deflection of M_3; *m-cu* a short distance beyond the fork of *M*.

Abdominal tergites dark brown, the sternites and hypopygium more yellowish. From the ventral surface of the ninth tergite arises a pair of long, slender lobes, directed caudad, their surface clothed with long, conspicuous setæ; these lobes extend caudad beyond the other elements of the hypopygium. Basistyles small, the ventro-mesal lobes long and exceedingly complex. Ventral dististyle fleshy, larger than

basistyle; dorsal dististyle a long, straight rod, the tip produced into an acute beak-like spine.

Holotype, ♂, Desierto de los leones, altitude about 3000 meters, September 23, 1923 (A. M. Dampf). *Paratopotypes*, 5 ♂♂, December 9, 1923; M. F. 67.

This very remarkable crane-fly is readily told from all described members of the genus by the filiform structures adorning the ninth tergite of the male hypopygium.

Dicranomyia melanocera sp. n.

General coloration yellowish pollinose, the praescutum with a dark brown median stripe; rostrum obscure yellow; palpi and antennae black; halteres short, the knobs infuscated; wings subhyaline; *Sc* relatively short; cell *1st* M_2 closed.

Male. Length about 4.5 mm.; wing, 5.4–5.5 mm.

Rostrum obscure yellow; palpi black. Antennae black throughout; flagellar segments oval. Head dark, brownish gray pruinose; vertex between eyes broad.

Mesonotum pale, yellowish pollinose, with a broad, dark brown median stripe that does not reach the suture; lateral stripes nearly obsolete; scutum dark gray; scutellum obscure yellow, more grayish basally; postnotal mediotergite gray. Pleura pale, sparsely pruinose, the posterior sclerites paler. Halteres short, yellow, the large knobs infuscated. Legs with the coxae pale, the fore coxae more infuscated; trochanters yellow; femora pale yellowish brown, passing into brown at the tips; tibiae brown, the tips dark brown; tarsi black. Wings (Fig. 5) subhyaline, the stigma oval, pale brown; veins darker brown. Venation: *Sc* relatively short, Sc_1 ending nearly its own length before the origin of the short *Rs*, the latter oblique, somewhat angulated; *Rs* only a little longer than the basal deflection of R_{4+5}; inner ends of cells R_3 and *1st* M_2 lying basad of cell R_5; cell *1st* M_2 closed, about equal to vein M_{1+2} beyond it; *m-cu* near fork of *M*, a little longer than the distal section of Cu_1.

Abdomen dark brown, the sternites paler; hypopygium pale brown. Male hypopygium (Fig. 16) with the basistyles (b) produced mesad into fleshy lobes. Ventral dististyle (v) large and fleshy, the rostrum stout with two close-set spines; dorsal dististyle relatively small, arcuated, the long tip acute. Gonapophyses (g) with the mesal lobe relatively slender, the tip subacute.

Holotype, ♂, Xochimilco, September 30, 1923 (A. M. Dampf). *Paratopotype*, ♂.

Dicranomyia dampfi sp. n.

Allied to *D. badia* (Walker); general coloration black, the small humeral angles of the praescutum paler; tips of femora obscure yellow; wings strongly tinged with brown, the oval stigma darker brown.

Male. Length about 7 mm.; wing, 9.6 mm.

Female. Length about 7.5 mm.; wing, 10 mm.

Rostrum, palpi and antennae black; flagellar segments oval. Head black.

Pronotum and mesonotal praescutum black, only the restricted humeral angles of the latter a little paler; posterior sclerites of mesonotum dark brown. Pleura black, the anterior portion of the propleura a little brighter; sternopleurite dark brown. Halteres blackish, the extreme base of stem pale. Legs with the coxae obscure brownish yellow, the fore coxae darker; trochanters obscure yellow; femora dark brown, the extreme bases paler, the narrow tips conspicuously obscure yellowish; tibiae and tarsi brownish black. Wings (Fig. 6) strongly tinged with brown, the stigma oval, darker brown; a paler cloud on anterior cord; paler areas before and beyond the stigma; veins brownish black. Venation: Sc_1 ending immediately beyond the origin of *Rs*, Sc_2 not far from the tip and before this origin; cell *1st* M_2 closed, a little shorter than vein M_{1+2} beyond it; *m-cu* close to fork of *M*.

Abdominal tergites dark brownish black, the sternites paler, yellowish brown, the bases of the individual segments a little brighter. Male hypopygium with the ventral dististyle very large and fleshy, the short rostrum with two acute spines, placed almost at the tip. Gonapophyses broad, the relatively short mesal lobe broad-based, gently curved, the subacute tip directed slightly laterad.

Holotype, ♂, Desierto de los leones, altitude about 3000 meters, September 23, 1923 (A. M. Dampf). *Allotopotype*, ♀.

This interesting *Dicranomyia* is named in honor of the collector, Dr. Alfons Dampf, to whom we are indebted for invaluable collections of Mexican insects and whose untiring efforts have done very much toward making known the interesting fauna of Mexico. The species is related to *D. badia* (Walker) from which it is told by the diagnostic characters listed above.

Limonia Meigen.

Limonia obtusistylus sp. n.

General coloration gray; head with two velvety-black lines that are confluent before and behind; mesonotal praescutum with three conspicuous dark brown stripes; wings grayish subhyaline, spotted with brown; *Sc* long; *m-cu* before the fork of *M;* male hypopygium with a bispinous rostrum; dorsal dististyle small, sickle-shaped, the tip obtusely rounded.

Male. Length about 4.5 mm.; wing, 6.6 mm.

Rostrum and palpi dark brown. Antennae dark brown, the extreme proximal ends of the basal flagellar segments indistinctly paler; flagellar segments oval. Head dark gray, the anterior vertex golden-yellow, the posterior vertex with a velvety-black stripe that divides shortly, following the orbits for a brief distance, thence directed caudad, becoming confluent on the occiput.

Pronotum gray, dark brown above. Mesonotal praescutum yellowish gray with three conspicuous dark brown stripes, the sublateral regions likewise indistinctly darkened; scutum grayish brown, indistinctly variegated with darker; scutellum light yellow; postnotum darkened. Pleura dark brown, heavily gray pruinose, interrupted to leave small patches of the ground-color. Halteres yellow, the knobs conspicuously dark brown. Legs with the coxae testaceous, sparsely pruinose; trochanters obscure yellow; remainder of legs broken. Wings (Fig. 7) grayish subhyaline, sparsely spotted with brown; ground-color clearest immediately before and beyond the stigma; subcostal cell largely occupied by three brown markings, restricting the ground-color to two small spots; stigma pale brown with the ends vaguely darker; wing-apex faintly suffused; the largest remaining spots are along the costal region, at tip of Sc_1, at origin and fork of *Rs;* cord and outer end of *1st* M_2 narrowly seamed; a series of small brown spots in cells *R* and *M*, with fewer scattered similar spots in cells *Cu* and *1st A;* veins dark brown. Venation: *Sc* long, Sc_1 extending to just before mid-length of *Rs;* Sc_2 not evident in the unique type; *m-cu* some distance before the fork of *M*.

Abdomen brown, sparsely variegated with darker. Male hypopygium (Fig. 17) with the caudal margin of the ninth tergite (t) conspicuously notched medially. Basistyle (b) relatively small, with a conspicuous hemispherical setiferous lobe on mesal face. Ventral dististyle (v) large and fleshy, the rostrum very small, with two long straight spines that are much longer than the rostrum alone; cephalic margin of rostrum with a fringe of seven or eight short setae. Dorsal dististyle a small sickle-shaped blade, the apex obtuse. Gonapophyses relatively small, appearing as flattened blades, the caudal mesal angle produced, the apex curved gently laterad.

Holotype, ♂, Desierto de los leones, altitude 3010–3080 meters, July 20, 1924 (A. M. Dampf); M. B. No. 73.

Limonia obtusistylus is generally similar to the species of the *simulans* group (*simulans* Walker, *concinna* Williston, etc.), differing very strikingly in the structure of the male hypopygium. The reference of the species in *Limonia* is based on the length of the subcostal vein.

Elephantomyia Osten Sacken.

Elephantomyia alticola sp. n.

General coloration gray; wings with a faint brown tinge, the costal margin and a conspicuous seam in cell *M* adjoining vein Cu_1 darker brown; abdominal tergites yellow, each segment with a T-shaped brown mark; sternites uniformly dark brown.

Male. Length, excluding rostrum, 8.2 mm.; wing, 11.5 mm.; rostrum alone, 5 mm.

Rostrum relatively short, brownish black; palpi concolorous. Antennae black, only the apex of the second scapal segment a trifle

paler. Head yellowish gray, the vertex between the eyes about one-third wider than the diameter of the first scapal segment.

Pronotum dark brown, heavily dusted with gray. Mesonotum dark brown, heavily dusted with gray, the praescutum more yellowish gray, the median area remaining broadly dark brown. Pleura dark gray, the dorso-pleural region buffy. Halteres obscure brownish yellow, the knobs darker brown. Legs with the coxae obscure yellow, their bases slightly darker; trochanters obscure brownish yellow; femora brown, the tips blackened, on the fore femora the black very extensive, including all but the basal fourth; posterior femora with the black tips narrow; tibiae and tarsi dark brown. Wings (Fig. 8) with a faint brown tinge, the costal margin and a conspicuous seam along vein Cu_1 in cell *M* darker brown, the two narrowly and indistinctly connected by a vague narrow seam along the cord; outer end of cell *1st* M_2 likewise indistinctly seamed; stigma oval, darker brown; veins dark brown. Venation: Sc_1 ending beyond two-thirds the length of *Rs*, Sc_2 a trifle longer; *Rs* strongly angulated and weakly spurred at origin; *m-cu* about two-thirds its length beyond the fork of *M*.

Abdominal tergites obscure yellow, the intermediate segments brighter colored, the segments with dark brown inverted T-shaped markings, the crossbar occupying the caudal margin of the segment; sternites uniformly dark brown.

Holotype, ♂, Mt. Tlaloc, region of *Abies religiosa*, altitude 2800–3200 meters, June 15, 1924 (A. M. Dampf); M. B. No. 67.

Elephantomyia alticola is very different from the described species of the genus.

Gonomyia Meigen.

Gonomyia (Gonomyia) **tuberculata** sp. n.

Belongs to the *cognatella* group; wings narrow, *Sc* short; *Rs* in alignment with R_{4+5}; cell *2nd A* narrow; male hypopygium with the outer dististyle produced into a darkened tubercle before midlength.

Male. Length, 3.5–3.6 mm.; wing, 4.8–5.6 mm.

Rostrum and palpi dark brown. Antennae with the scapal segments conspicuously light yellow; flagellum abruptly dark brown. Head yellow, the center of the vertex with a brownish black spot.

Pronotum dark brown, yellow on the sides. Mesonotal praescutum with three dark brown stripes, the interspaces only a trifle paler so the dorsum appears almost uniformly dark; lateral margins of the praescutum broadly yellow; scutum dark brown, the median area narrowly obscure yellow; scutellum brown, the margins broadly yellow; postnotal mediotergite with a ⊥-shaped brown mark. Pleura light yellow with a narrow dorsal dark brown stripe passing immediately above the base of the halter to the postnotal mediotergite; sternopleurite less distinctly darkened. Halteres elongate, the knobs and base of the stem dark brown, the remainder of the stem paler. Legs with the coxae and trochanters testaceous; remainder of legs dark brown, the femoral

bases paler. Wings (Fig. 9) narrow, with a faint brownish tinge; stigma oval, darker brown; veins dark brown. Venation: *Sc* very short, Sc_1 ending a distance before the origin of *Rs* that is approximately equal to the length of the latter vein alone, Sc_1 short; *r-m* joining *Rs* immediately before its fork; *Rs* in alignment with R_{4+5}; cell R_2 relatively large; cell *2nd* M_2 deep; *m-cu* at fork of *M*; cell *2nd A* narrow.

Abdominal tergites dark brown, the sternites and hypopygium yellow. Male hypopygium (Fig. 18) with the basistyle (b) produced into a cylindrical fleshy lateral lobe and a smaller mesal lobe. Outer dististyle an elongate, clavate, fleshy lobe, the mesal margin near midlength produced into a darkened tubercle. Inner dististyle complex, tripartite, consisting of a flattened paddle-like blade with a single seta on the disk; a fleshy setiferous lobe that terminates in two powerful fasciculate setae, and a powerful chitinized spine, the latter varying in degree of stoutness in different specimens. Aedeagus (a) curved. Gonapophyses (g) asymmetrical, the longest very slender, curved, terminating in a long acute spine; the second apophyse is small, gently sinuous.

Holotype, ♂, Penon marquez, March 5, 1924 (A. M. Dampf); M. B. No. 36. *Paratopotypes*, 2 ♂ ♂. *Paratypes*, 3 ♂ ♂, Penon viejo, May 11, 1924; M. B. No. 50; 2 ♂ ♂, Desierto de los leones, in swampy meadow, January 25, 1925; M. B. No. 114.

Gonomyia tuberculata is allied to *G. delicata* Alexander (Guatemala), differing especially in the structure and venation of the wings. The male of the latter species is still unknown.

Molophilus Curtis.

Molophilus severus sp. n.

General coloration dark brown; antennae short; knobs of halteres bright yellow; male hypopygium with the basal dististyle a powerful gently curved, chitinized rod that is gradually narrowed to the acute tip.

Male. Length, 3.6–3.8 mm.; wing, 5–5.2 mm.

Female. Length about 4.5 mm.; wing, 6.2–6.3 mm.

Rostrum and palpi black. Antennae short, black throughout; flagellar segments oval with relatively long setae. Head dark gray.

Pronotum dark brown, the sides obscure yellow. Mesonotal praescutum reddish brown, the median area broadly darker brown, the humeral region narrowly obscure yellow; scutal lobes darkened; scutellum and postnotum dark. Pleura dark brown. Halteres pale yellow, the intermediate portion of the stem indistinctly darker, the knobs brighter yellow. Legs with the coxae brownish testaceous; trochanters testaceous yellow; femora pale brownish yellow, the tips narrowly and indistinctly darkened; tibiae brownish yellow, the tips and the tarsi dark brown. Wings with a strong brown tinge, the stigmal region darker; prearcular region indistinctly more yellowish; veins dark brown. Venation: Vein *2nd A* elongate, running generally

parallel to *1st A*, ending opposite the basal portion of the petiole of cell M_3.

Abdomen dark brown, including the hypopygium. Male hypopygium with the basistyle terminating in a minute compressed beak, the apex of which is acute. Outer dististyle elongate, curved, bifid, the longest arm slender and strongly angulated near midlength, the shorter arm dilated and squarely truncated at apex. Basal dististyle (Fig. 19) a powerful, gently curved chitinized rod, gradually narrowed to the acute tip, the concave margin on basal half microscopically serrulate.

Holotype, ♂, Desierto de los leones, altitude 3010–3080 meters, July 20, 1924 (A. M. Dampf); M. B. No. 73. *Allotopotype*, ♀. *Paratopotypes*, 40 ♂ ♀; *paratype*, ♂, Chapingo, July 14, 1924; M. F. 237.

Molophilus paucispinosus sp. n.

General coloration dark brownish gray; knobs of halteres whitish; wings strongly infumed; vein *2nd A* relatively short; male hypopygium with the basal dististyle terminating in a few strong spines.

Male. Length about 3.2 mm.; wing, 3.5 mm.

Rostrum and palpi brownish black. Antennal scape black, the flagellum broken. Head dark gray.

Pronotum dark, only the lateral portions of the posterior notum obscure yellow. Mesonotum dark brownish gray, the humeral region of the praescutum vaguely brighter. Pleura dark brown, very sparsely pruinose. Halteres pale, the knobs whitish. Legs dark brown. Wings strongly infumed, the stigmal region scarcely darker; veins and macrotrichiae still darker brown. Venation: Sc_1 ending opposite *r;* vein *2nd A* relatively short, ending a short distance before *m-cu*.

Abdomen dark brownish black, including the hypopygium. Male hypopygium with the outer dististyle bifid, the longest arm slender, gently curved, the short arm flattened, the apex truncated and gently sinuous. Basal dististyle (Fig. 20) a short powerful chitinized rod that terminates in a few strong spines; margin of style near midlength with a single elevated tubercle that bears a short powerful seta.

Holotype, ♂, Desierto de los leones, altitude 3010–3080 meters, July 20, 1924 (A. M. Dampf); M. B. No. 73.

The two species of *Molophilus* described herewith are very distinct from all allied regional species in the structure of the male hypopygium.

Erioptera Meigen.

Erioptera (Mesocyphona) **inornatipes** sp. n.

General coloration light brown, the praescutum with two conspicuous dark brown stripes; pleura with a grayish white longitudinal stripe enclosed between two narrow brown vittae; legs uniformly

brown; wings brown, spotted and dotted with white, the costal region basad of the origin of *Rs* largely pale.

Male. Length, 3.3–3.5 mm.; wing, 4.2-4.4 mm.

Female. Length, 4 mm.; wing, 5–5.2 mm.

Rostrum brown; palpi black. Antennae brown, the flagellum a little paler; flagellar segments oval. Head grayish brown.

Pronotum brown, darker medially. Mesonotal praescutum light brown with two conspicuous dark brown stripes that are separated from one another by a very slightly narrower median line of the ground-color; extreme lateral margin of sclerite narrowly dark brown; pseudosutural foveae and tuberculate pits in transverse alignment, black; scutal lobes with their mesal edges blackened; scutellum brown, broadly margined with ochreous; postnotum gray. Pleura gray with two ill-defined, narrow brown longitudinal stripes that enclose a dirty grayish white band that passes immediately beneath the root of the halter; sternopleurite grayish. Halteres pale, the knobs dark brown. Legs with the coxae and trochanters pale brown; remainder of legs brown, the femora only vaguely darkened at their tips; terminal tarsal segments somewhat darker in color. Wings (Fig. 10) brown, the costal margin darker, the remaining cells paler in color, the entire surface variegated with numerous whitish dots and spots, arranged in more or less contiguous to confluent longitudinal rows in the cells, restricting the ground-color to a reticulate pattern; costal region before the origin of *Rs* extensively whitish cream color; a small spot before the posterior arculus darker brown; the three larger brown costal blotches much wider than the pale spots between; a pale band along the cord to Cu_1; veins brown, pale in the whitish areas. Venation as in the subgenus.

Abdomen light grayish brown, including the hypopygium. Ovipositor with the tergal valves yellowish horn-color, the sternal valves darker.

Holotype, ♂, Peñon viejo, May 11, 1924 (A. M. Dampf); M. B. No. 50. *Allotopotype*, ♀. *Paratopotypes*, 18 ♂ ♀; *paratypes*, Peñon marquez, 1 ♂, March 13, 1924; M. B. 34; 5 ♂ ♀, March 5, 1924, M. B. Nos. 36, 37; 20 ♂ ♀, Desierto de los leones, swampy meadow, January 25, 1925; M. B. 114.

Erioptera inornatipes is well distinguished from the allied species of the subgenus *Mesocyphona* by the unornamented legs.

Erioptera (Empeda) **ochricauda** sp. n.

Size large (wing, ♂, over 7 mm.); general coloration dark brown, variegated with yellowish; pleura striped longitudinally with brown and yellow; legs brownish black.

Male. Length about 5 mm.; wing, 7.2 mm.

Rostrum light ochreous; palpi infuscated. Antennae with the scapal segments paler than the dark brown flagellum; flagellar segments oval, becoming more elongate outwardly, the verticils relatively short and inconspicuous. Head light gray.

Pronotum brown medially, the sides more yellowish; lateral pretergites conspicuously light yellow. Mesonotum dark grayish brown, the lateral margins of the praescutum conspicuously orange-yellow; pseudosutural foveae and tuberculate pits shiny brownish black; scutellum grayish brown, bordered posteriorly by obscure brownish yellow. Pleura obscure yellow, longitudinally variegated with brown, the more dorsal stripe including the fore coxa and the dorsal anepisternum; ventral stripe including the sternopleurite and meron, the pteropleurite remaining largely pale. Halteres pale yellow. Legs with the fore coxae dark, the other coxae obscure yellow; trochanters brownish yellow; remainder of legs brownish black, only the extreme femoral bases paler. Wings with a pale grayish tinge, the costal region a little darker; anal angle of wing weakly infuscated; veins brown; *Rs*, *M* and *1st A* conspicuously paler. Venation: Sc_1 ending beyond midlength of *Rs*, Sc_2 some distance from its tip, Sc_1 alone more than one-half longer than *r-m; r* about its own length beyond the fork of *Rs;* basal deflection of M_{1+2} very short; *m-cu* near fork of M.

Abdomen dark brown, the sternites somewhat paler; hypopygium ochreous. Male hypopygium with the outer dististyle (Fig. 21) bifid, the outer or longer arm relatively broad, parallel-sided, the apex obtuse; the shorter or mesal arm broadest just beyond midlength, thence suddenly narrowed to a blunt point. Inner dististyle gently expanded distally.

Holotype, ♂, Mt. Tlaloc, *Pinus* region, altitude about 3700 meters, on wet rocks, June 15, 1924 (A. M. Dampf).

Erioptera ochricauda is readily distinguished from the known species of *Empeda* by the large size, striped thoracic pleura and other characters as diagnosed.

Erioptera (Empeda) **alticola** sp. n.

General coloration gray; antennae and legs black throughout; halteres pale, the knobs infuscated; wings tinged with brownish gray, the extreme base more yellowish.

Male. Length about 4.8 mm.; wing, 6.2–6.3 mm.

Female. Length about 4.4 mm.; wing, 5.8 mm.

Rostrum dark gray; palpi black. Antennae black throughout, the segments with long verticils. Head gray.

Pronotum broadly dark brown medially, the sides narrowly grayish. Mesonotal praescutum dark brown, the sides of the sclerite fading into light gray, only the very narrow pretergites and dorsopleural membranes a trifle buffy; posterior sclerites of mesonotum clear light gray. Pleura uniformly light gray. Halteres pale, the knobs infuscated. Legs with the coxae dark gray, the remainder of the legs black. Wings with a faint brownish gray tinge, the oval stigma faintly indicated, pale brown; wing-base and costal region a little more yellowish; veins brown.

Abdomen dark brown, including the hypopygium. Male hypopygium with the outer dististyle (Fig. 22) bifid, the shorter or mesal arm squarely

truncated and with the inner angle produced laterad into a point; outer arm relatively slender and gently curved.

Holotype, ♂, Mt. Tlaloc, *Pinus*-region, altitude 3000–3600 meters, June 15 1924 (A. M. Dampf). *Allotopotype*, ♀, *Abies*-region, altitude 2800-3200 meters, June 15, 1924; M. B. No. 67. *Paratopotypes*, 4 ♂ ♀.

Erioptera alticola is readily told from all described species of the subgenus by the comparatively large size, nearly uniformly gray coloration and black antennæ and legs.

Erioptera (Empeda) **curta** sp. n.

General coloration pale brown, variegated with yellow; head yellow, the vertex variegated with brown; antennae pale at base; thoracic pleura yellow, indistinctly striped with darker; wings with *Sc* short; male hypopygium with an obtuse lobe in the axil of the arms of the outer dististyle.

Male. Length about 4.4 mm.; wing, 4.7 mm.

Rostrum yellow; palpi brown. Antennae with the basal segment of scape yellow, the second segment passing into brown; flagellum brown, the segments short-oval, with verticils of moderate length. Head yellow, the center of the vertex infuscated.

Pronotum yellow, narrowly brown medially. Mesonotal praescutum pale brown, further divided by a dark brown median vitta that becomes obsolete shortly beyond the pseudosutural foveae, the lateral margins of the sclerite narrowly yellow; pseudosutural foveae shiny chestnut-brown; scutum obscure brownish yellow, each lobe with two confluent brown spots, the posterior mesal one smaller; scutellum yellow, the median area at base weakly infuscated; postnotum weakly infuscated. Pleura obscure yellow with two ill-defined darker longitudinal vittae, the more dorsal including the fore coxa and occupying the anepisternum, the more ventral somewhat darker, including the sternopleurite and meron. Halteres pale, the knobs infuscated. Legs with the fore coxae darkened, as described above, the other coxae pale; trochanters pale yellow; remainder of legs pale yellow, the terminal segments passing into dark brown. Wings yellowish gray, the base, costal region and space between the branches of *Cu* (as interpreted by Tillyard) more yellowish; veins brown, more yellowish in the flavous areas. Venation (Fig. 11): *Sc* very short, Sc_1 ending before one-third the length of the short *Rs*, Sc_2 not far from its tip.

Abdomen dark brown, the caudal and caudo-lateral portions of the basal segments more yellowish, the latter increasing in amount on the posterior segments, very extensive on the penultimate segment; sternites yellowish; hypopygium pale. Male hypopygium with the outer dististyle (Fig. 23) bifid, the longest arm with a prominent basal wing or flange that is approximately rectangular in outline; the shorter curved arm has a conspicuous obtuse lobe on the inside near base, this lobe having approximately the same outline as the two arms.

Holotype, ♂, Chapingo, August 13, 1924 (A. M. Dampf); M. F. 291.

Erioptera curta is readily distinguished from all described species of the subgenus by the short subcosta and the structure of the male hypopygium.

Erioptera (Empeda) **tridentata** sp. n.

General coloration pale yellow; wings pale yellowish subhyaline, the veins pale; male hypopygium with the outer dististyle bifid, the mesal arm with a conspicuous group of three spines near its axil.

Male. Length, 2.8–3 mm.; wing, 4.8 mm.

Female. Length, 3.8 mm.; wing, 5.2 mm.

Rostrum pale yellow, the palpi a trifle darker. Antennae yellow, the terminal segments passing into darker; flagellar segments of the male with relatively long verticils. Head pale yellow; vertex in the male very narrow, in the female somewhat broader.

Pronotum pale yellow. Mesonotal praescutum and scutum with the disk pale reddish yellow, the margins pale yellow; remainder of mesonotum pale yellow. Pleura yellowish white. Halteres pale throughout. Legs pale yellow, only the terminal tarsal segments infuscated. Wings very pale yellowish subhyaline, the veins scarcely darker, inconspicuous. Venation: Sc_1 ending near midlength of *Rs*, Sc_1 a little shorter than *r-m*; *r* just before midlength of R_{2+3}; veins R_2 and R_3 divergent; anal veins strongly divergent.

Abdomen obscure yellow, including the hypopygium. Male hypopygium with the outer dististyle (Fig. 24) profoundly bifid, the outer arm longer, curved, the shorter mesal arm terminating in a broad flattened blade with a conspicuous group of three spines on the inner margin just beyond the base.

Holotype, ♂, Desierto de los leones, altitude 3010–3080 meters, July 20, 1924 (A. M. Dampf); M. B. No. 73. *Allotopotype*, ♀. *Paratopotypes*, 5 ♂ ♀.

Erioptera tridentata is readily distinguished from all described species of *Empeda* by the uniformly pale yellow coloration and structure of the male hypopygium.

Erioptera (Empeda) **unidentata** sp. n.

Male. Length about 3.4 mm.; wing about 3.8 mm.

Closely related to *E.* (*E.*) *tridentata* sp. n., from which it differs in slight details of coloration and the structure of the male hypopygium.

Rostrum obscure yellow; palpi infuscated. Antennae with the scapal segments yellowish testaceous, the flagellum brown; flagellar segments with long verticils. Head clear light gray.

Mesonotum light reddish brown, the praescutum with a vague dusky median line on the anterior half, this becoming obsolete at the tuberculate pits, the latter black; pseudosutural foveae pale. Pleura

pale reddish brown. Halteres pale, the knobs weakly infuscated. Legs with the coxae pale, the fore coxae extensively infuscated; trochanters pale; legs largely pale, the fore femora darker; tarsi passing into brown. Wings tinged with grayish, the base and costal region more yellowish; veins pale. Venation: *r* on R_{2+3} only a trifle more than its length beyond the origin.

Abdomen pale brown, the hypopygium paler. Male hypopygium with the outer dististyle (Fig. 25) bifid, the shorter mesal arm bearing a single powerful spine just before midlength. In the related *E.* (*E.*) ***nigrolineata*** (Enderlein), there is a similar solitary spine, which, however, is borne in the axil of the two arms.

Holotype, ♂, Desierto de los leones, altitude 3010–3080 meters, July 20, 1924 (A. M. Dampf); M. B. No. 73.

Tipula Linnæus.

Tipula moctezumæ sp. n.

General coloration gray, the praescutum with four uniformly dark brown stripes; antennae short, the basal segment of the flagellum very long; abdominal tergites obscure yellow, striped longitudinally with dark brown; ninth tergite broad, pale; inner dististyle divided into two blackened arms.

Male. Length, 14–15 mm.; wing, 18.5–19.5 mm.

Frontal prolongation of head obscure brownish yellow, darker medially above; nasus moderately long, dark; palpi dark brown. Antennae short, scape and first segment of flagellum orange; intermediate flagellar segments indistinctly bicolorous, dull orange, the basal enlargement of each darker, the terminal flagellar segments passing into uniform dark brown; first flagellar segment very long, exceeding in length the combined following three segments; basal swellings of intermediate flagellar segments relatively small and inconspicuous. Head gray, the small vertical tubercle a trifle more yellowish.

Mesonotal praescutum dark gray with four uniform dark brown stripes, the intermediate pair rather broadly separated from one another; scutum dark gray, each lobe with two separate brown areas; scutellum gray with an indistinct brown median line; postnotum gray. Pleura brownish gray, indistinctly variegated with darker areas. Halteres pale, the knobs infuscated. Legs long and slender, the coxae brownish gray; trochanters brownish yellow; femora brownish black, the bases indistinctly and restrictedly paler, the tips blackened, the segments with a more or less distinct subterminal paler ring, more distinct on the posterior legs; tibiae dark brown, the tips and the tarsi blackened. Wings with the center of the disk whitish subhyaline, the base and costal region more yellowish, the apical and anal cells weakly infuscated, the stigma small, ill-defined and only slightly darker than the ground-color; the pale areas occupy most of cells *R* and *M*, the broad bases of the anal cells, cell *1st* M_2, all of R_5 except the base and the base of cell M_3; a rather broad and conspicuous brown seam occupies the distal half of vein Cu_1, slightly narrower on *m-cu;* veins dark brown, more

yellowish in the flavous areas. Venation: R_2 complete, but the distal two-thirds pale and without macrotrichiae; petiole of cell M_1 variable, equal to or shorter than *m; m-cu* connecting with M_4 shortly beyond its origin.

Abdominal tergites obscure yellow with a narrow dark brown median and two broader lateral stripes that widen out behind, on the fourth and succeeding segments gradually eliminating the ground-color, the subterminal segments uniformly darkened, pruinose; basal sternites yellow, the subterminal segments darkened; hypopygium pale. Eighth sternite produced medially into a small flattened liguliform lobe that lies closely appressed to the ninth sternite. Male hypopygium with the ninth tergite (Fig. 26) broad, notched medially, the lateral angles produced caudad into rather broad obtuse lobes. Tergite entirely separate from the sternite; basistyle virtually complete. Outer dististyle pale, more or less constricted near midlength. Inner dististyle deeply divided into an inner and a slightly smaller outer arm, each being spatulately dilated and blackened distally; the outer dististyle lies far ventrad near the ventral portion of the basistyle, its usual dorsal position being occupied by the outer chitinized arm of the inner style.

Holotype, ♂, Mt. Tlaloc, *Pinus-region*, altitude 3000–3600 meters, June 15, 1924 (A. M. Dampf); M. B. No. 63. *Paratopotypes*, 5 ♂ ♂, M. B. Nos. 63, 67.

Tipula moctezumæ is readily distinguished from all similar regional forms by the very long third antennal segment and the peculiar structure of the hypopygium.

Tipula azteca sp. n.

General coloration gray, the praescutum with the lateral stripes nearly obsolete; antennae moderately elongate, flagellum black; male hypopygium without a median liguliform lobe on eighth sternite.

Male. Length about 12–12.5 mm.; wing, 14–15 mm.

Frontal prolongation of head relatively elongate, brown, the dorsum, including the long nasus, gray; palpi with basal segment pale brown, the remainder brownish black. Antennae of moderate length, if bent backward extending approximately to the base of the abdomen; basal segment dark brown, the second segment conspicuously yellow; flagellum black, the segments moderately incised. Head light gray, the small, simple vertical tubercle more yellowish.

Mesonotal praescutum gray, more infuscated anteriorly and laterally, with the usual brown stripes often very feebly indicated, especially the lateral pair, which are virtually obsolete; intermediate pair darker, broadened and confluent in front, strongly narrowed behind, not attaining the suture; scutum light gray, each lobe with a large triangular darker gray marking; scutellum light gray; postnotum yellowish gray. Pleura gray, the dorso-pleural membrane more brownish. Halteres elongate, pale yellow, the knobs infuscated. Legs with the coxae light gray; trochanters obscure orange; remainder of legs black, the extreme

femoral bases indistinctly paler. Wings extensively whitish subhyaline, the base and cells *C* and *Sc* conspicuously yellow; faint brown clouds include most of cells *1st* R_1, *2nd* R_1, R_2 and R_3; faint and restricted marginal clouds in cells M_1 to M_4; a conspicuous triangular cloud in end of cell *1st A* at about mid-distance between the anal veins, extending basad for about one-third the length of the cell; veins narrowly seamed with brown, broader and more conspicuous on the distal half of Cu_1. Venation: R_2 entire, quite without macrotrichiae; vein *1st A* running parallel with Cu_2 for its basal third, thence diverging gradually to the margin, cell *1st A* thus being very wide.

Basal abdominal tergites obscure yellow, with a narrow median dark brown stripe and broader paler brown lateral stripes, the latter on the third and succeeding segments broadening out to include the entire segments; sternites beyond the extreme base infuscated; hypopygium pale. Male hypopygium very similar in structure to that of *T. moctezumæ* sp. n., differing as follows: 9th tergite without the smaller median U-shaped notch, there being only a linear split; lateral lobes more obliquely truncated. Eighth sternite without median liguliform lobe.

Holotype, ♂, Mt. Tlaloc, summit, at nearly 4000 meters; treeless, with grass and creeping *Cupressus* between the rocks, June 15, 1924, (A. M. Dampf); M. B. No. 64. *Paratopotypes*, 2 ♂ ♂.

Tipula azteca is unquestionably closely related to *T. moctezumæ* in the peculiar structure of the hypopygium, differing most evidently in the small size, length and structure of the antennae and the details of the hypopygium.

Nephrotoma Meigen.

Nephrotoma dampfi sp. n.

General coloration yellow; mesonotal praescutum with three confluent shiny black stripes; head with the occipital brand very extensive, steel-gray, narrowly margined with velvet-black; a small black spot adjoining eye at narrowest part of vertex; abdomen orange-yellow, the tergum with a continuous black median stripe.

Male. Length, 8–9 mm.; wing, 9.5–11.2 mm.

Frontal prolongation of head pale yellow, the dorsum narrowly dark brown, the nasus concolorous; palpi brownish black. Antennae black throughout; flagellar segments only moderately incised. Head orange, passing into yellow on the genae and beneath; occipital brand very large, covering most of the vertex, shiny steel-gray, narrowly margined with velvety black, the latter continued cephalad as a small median spur onto the orange, slightly bifid vertical tubercle; a small but conspicuous black spot on either side of the vertex at the narrowest point, touching the margin of the eye.

Pronotum light yellow, the pleura extensively dark brown. Mesonotal praescutum yellow, the dorsum with three confluent shiny black or gray-black stripes, the anterior lateral margins with a small opaque black spot; a small black spot on lateral margin of praescutum just cephalad of suture; scutum yellow, each lobe largely occupied by a shiny gray-black stripe that extends obliquely across the lobe, the mesal margins parallel; scutellum pale brownish with a narrow median black vitta; postnotal mediotergite yellow with a ⊥-shaped brown marking. Pleura sulphur-yellow, variegated with black, the most conspicuous markings consisting of two short longitudinal stripes occupying the anepisternum and sternopleurite, divided by a yellow stripe; meron restrictedly blackened; a linear black streak immediately cephalad of each halter on the postnotal pleurotergite. Halteres brown, the base of the stem paler, the knobs extensively pale sulphur-yellow. Legs with coxae yellow, the fore coxae extensively darkened basally; trochanters orange-yellow; remainder of legs black, the femoral bases narrowly pale brown. Wings subhyaline, cells *C* and *Sc* more yellowish; outer ends of marginal radial cells faintly darkened; stigma oval, brown. Venation (Fig. 12): Sc_2 ending opposite origin of *Rs; m-cu* oblique, connecting with *M* some distance before its fork.

Abdominal tergites orange-yellow, with a continuous median black stripe extending to the ninth tergite, broadening out behind; sternites concolorous, with a dark spot laterally at base; base of eighth sternite extensively blackened basally; hypopygium pale. Eighth sternite notched medially, the margins of the notch fringed with conspicuous yellow setae. Male hypopygium with the ninth tergite deeply notched caudally.

Holotype, ♂, Mt. Tlaloc, *Pinus*-region, altitude 3000–3600 meters, June 15, 1924 (A. M. Dampf); M. B. No. 63. *Paratopotypes*, 12 ♂♂; M. B. Nos. 63, 69.

Nephrotoma dampfi is named in honor of Dr. Dampf, who collected the types on Mt. Tlaloc. This very distinct fly is readily distinguished from other species by the small size, curious head pattern and confluent praescutal stripes.

EXPLANATION OF FIGURES.

Symbols: Venational: Cu—Cubitus; M—Media; R—Radius; A—Anal. Hypopygial: a—aedeagus; b—basistyle; d—dorsal dististyle; g—gonapophyse; t—ninth tergite; v—ventral dististyle.

Plate XXIV.

Fig. 1. Wing of *Dicranomyia præpostera* sp. n.
Fig. 2. Wing of *D. ravida* sp. n.
Fig. 3. Wing of *D. tricornis* sp. n.
Fig. 4. Wing of *D. filicauda* sp. n.
Fig. 5. Wing of *D. melanocera* sp. n.
Fig. 6. Wing of *D. dampfi* sp. n.
Fig. 7. Wing of *Limonia obtusistylus* sp. n.
Fig. 8. Wing of *Elephantomyia alticola* sp. n.
Fig. 9. Wing of *Gonomyia tuberculata* sp. n.
Fig. 10. Wing of *Erioptera inornatipes* sp. n.
Fig. 11. Wing of *E. curta* sp. n.
Fig. 12. Wing of *Nephrotoma dampfi* sp. n.

Plate XXV.

Fig. 13. Male hypopygium of *Dicranomyia præpostera* sp. n.
Fig. 14. Male hypopygium of *D. ravida* sp. n.
Fig. 15. Male hypopygium of *D. tricornis* sp. n.
Fig. 16. Male hypopygium of *D. melanocera* sp. n.
Fig. 17. Male hypopygium of *Limonia obtusistylus* sp. n.
Fig. 18. Male hypopygium of *Gonomyia tuberculata* sp. n.
Fig. 19. Basal dististyle of *Molophilus severus* sp. n.
Fig. 20. Basal dististyle of *M. paucispinosus* sp. n.
Fig. 21. Outer dististyle of *Erioptera ochricauda* sp. n.
Fig. 22. Outer dististyle of *E. alticola* sp. n.
Fig. 23. Outer dististyle of *E. curta* sp. n.
Fig. 24. Outer dististyle of *E. tridentata* sp. n.
Fig. 25. Outer dististyle of *E. unidentata* sp. n.
Fig. 26. Ninth tergite of *Tipula moctezumae* sp .n.

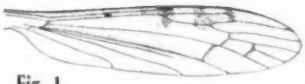

Fig. 1

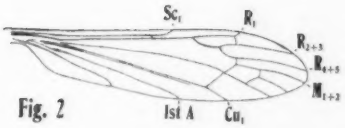

Fig. 2

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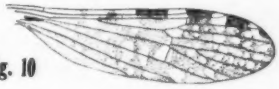

Fig. 10

Fig. 11

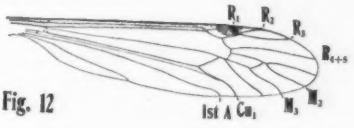

Fig. 12

Charles P. Alexander

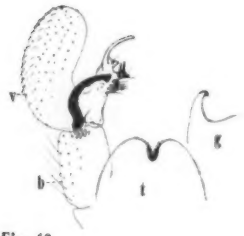

Fig. 13

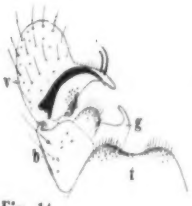

Fig. 14

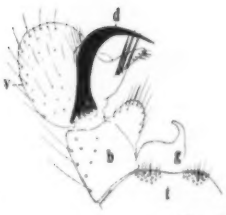

Fig. 15

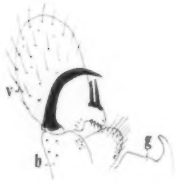

Fig. 16

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 21

Fig. 22

Fig. 23

Fig. 24

Fig. 25

Fig. 26

PHYSIOLOGICAL VARIATION IN THE SNOWY TREE-CRICKET, OECANTHUS NIVEUS DE GEER.*

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One of the most copied mistakes in entomological literature is one which was made by C. V. Riley and other writers of his time, on the oviposition of the Snowy Tree-cricket (*Oecanthus niveus* De Geer). At that time many entomologists did not clearly distinguish between the two species, which in the eastern states are commonly associated in raspberry and blackberry bushes. The more common species in such situations is *Oecanthus nigricornis* Walker, which deposits its eggs in conspicuous rows in the berry canes, while *O. niveus* places its eggs singly by the side of the leaf axils, where they easily escape observation. Riley (1) figured the eggs of the former species under the name of the latter. This error has been copied many times and can still be found in new publications at least as recently as 1918.

Observations by several entomologists have led to a correct understanding of the habits of the two species. Packard (2) gives an account of *O. niveus* depositing its eggs singly in elm bark, but did not question the validity of Riley's statement. Houghton (3) (4) in 1904, reared *O. niveus* from singly deposited eggs in plum bark and in 1909 reared *O. nigricornis* from eggs deposited in rows in elder. Parrott (5) in 1909, showed by cage experiments that *O. niveus* preferred apple to raspberry for oviposition and that *O. nigricornis* was responsible for the rows of eggs in raspberry and blackberry canes. Parrott and Fulton (6) in 1913, describe and illustrate the eggs of *O. niveus*, as they are deposited on raspberry and blackberry, in the thickened cortex by the side of the leaf axils, rarely at other points, and never extending into the pith, (Fig. 1, B). The insect is here following the same method, which it uses on apple and other trees, that of depositing the eggs singly in the bark,

*Contribution from the Dept. of Zoology and Entomology; Iowa tSate College. Acknowledgments are due to the Oregon Agricultural Experiment Station, with which the writer was connected while much of the data given in this paper was being obtained.

but on berry canes and other thin barked plants the cortical layer is not thick enough for their purpose except at the leaf axils. *O. nigricornis* prefers to oviposit in close set rows in pithy plants and the eggs lie in a slanting direction, imbedded in the pith, (Fig. 1, A). When this species occasionally oviposits on a woody plant, such as apple, it places the eggs in the young twigs in the same manner.

Shortly after the writer moved to Corvallis, Oregon, he was called upon to identify some tree-cricket eggs deposited in a raspberry cane in a long compact row, exactly as described above for *O. nigricornis*. Without hesitation he named them as such. The piece of cane was not thrown away and on the following day, June 13, four young crickets were found with it. An examination of these specimens revealed not young *O. nigricornis*, but something identical with the first instar *O. niveus* as observed in the east. It was something of a surprise to the writer to have his firmly established conceptions about the oviposition of tree-crickets so rudely upset. The only possible explanation seemed to be that this was a new species closely related to *O. niveus*. Curiously enough, the known species most closely related to *O. niveus*, namely *O. angustipennis* Fitch and *O. exclamationis* Davis, both have egg laying habits very similar to the first species. So far as known the habit of placing the eggs in rows in the pith was confined to the closely related species *O. nigricornis* Walker, *O. quadripunctatus* Beutenmuller and *O. pini* Beutenmuller.

This type of oviposition, i. e., rows of eggs in the pith, was found very commonly among raspberries, blackberries and loganberries in western Oregon. No eggs could be found deposited after the method of *O. niveus* on such plants, i. e., singly by the leaf axils. An examination of prune and apple trees showed that they also contained tree-cricket eggs, deposited singly in the bark in the same manner employed by *O. niveus* on these trees in New York State.

Two Races of *Oecanthus niveus* in Oregon.

In late summer, when the tree crickets had matured, it became apparent that the crickets, which were so numerous on berries as well as those found on prune and apple trees, were practically identical with the *O. niveus* of the east. Series of specimens collected both from bushes and trees were carefully

and minutely compared with each other and with specimens of *O. niveus* from Geneva, New York. No morphological or color characters could be found which would separate any one group from the others.

Observations on the song of the Oregon tree crickets showed that they had the intermittent, rhythmical, whistling notes characteristic of *O. niveus* in the east, but in this connection a most remarkable situation was found—in that those living in the fruit trees had a frequency of notes almost twice as great as those living on the berry bushes. This difference could not be accounted for on the basis of temperature or other environmental factors.

It seemed evident that there were two races of the Snowy Tree-cricket in Oregon, one living on berry bushes and the other on fruit trees. The writer set out to make a more detailed study of the life habits and ecological distribution of each form and to see if they retained their habits if transferred from one environment to the other.

For convenience in describing further the habits of the two races they will be designated as *O. niveus* A for the arboreal form and *O. niveus* B for those living in bushes.

Ecological Distribution.

The *O. niveus* of the eastern states is not only found on a great variety of trees, but is also a regular inhabitant of berry bushes and many other low shrubs.

O. niveus A is strictly arboreal. In the vicinity of Corvallis, Oregon, this form is most common on prune and apple and in the native growths of white ash and Gary Oak. I have also heard it singing in cherry, maple and poplar trees. It is usually more abundant among the higher branches and could be heard singing in the tops of quite large trees. The only berry bushes I have found it in were tall, coarse blackberries growing under trees.

O. niveus B is preeminently a bush inhabiting form. It is very common on loganberry and raspberry, and to a somewhat less extent, on blackberry. It occurs abundantly in the wild rose thickets, which are so common in the Willamette Valley. It is widely distributed though not abundant, among the brake ferns and associated plants in old burned areas in the Coast Range.

At the edge of a deciduous woods where there is a scrubby growth of young trees and bushes the ecological ranges of the two forms come together, but the extent of such contact is relatively small. Occasionally in such places both races may be heard singing in the same bush or small tree.

In this connection it is interesting to note that *Oecanthus nigricornis*, which is the most common inhabitant of berry bushes in the east, is not found in such situations in western Oregon. The closely related species or western variety, *O. argentinus* Saussure, is rarely found on berry bushes. Its distribution is usually confined to medium sized weeds in open fields and prairies.

Oviposition.

The eggs of *O. niveus* A are placed singly in the bark of trees, (Fig. 1, C). In prune and ash trees they were found in branches from one to three inches in diameter. On ash trees they were usually located near side branches where the bark is somewhat thickened and rough. Eggs found on a vertical or sloping branch were most often located above the puncture, but there is considerable variability on this point. On horizontal or sloping branches, 75 per cent or more were located on the lower side. The females evidently prefer to work head downward on the lower side of a branch. Our observations on the species at Geneva, New York, show that the females there usually oviposit head uppermost on the upper side of a branch. A pellet of excrement is often used by *O. niveus* A to stop up the hole after the egg is deposited, as is the case in the eastern states. In cage experiments with form A, it was later found that plugs of chewed bark were sometimes used. This we have never observed in the eastern form.

The eggs of *O. niveus* B are placed in compact rows with the eggs all slanting across the pith, (Fig. 1, A). Most rows average about one egg per millimeter, but occasionally they are more scattered. The number of holes per row varies from 2 to 40. Rows of 10 to 20 are common. In vertical stalks the eggs usually extend downward from the point of oviposition, or in other words, the female works head uppermost, which is at variance with race A, but agrees with *O. niveus* in New York and Iowa. On horizontal or sloping branches most of the punctures are drilled on the underside. This habit agrees with race A, but

in the east *O. niveus* usually oviposits on the upper side of a branch. After depositing the egg, race B covers the puncture with chewed bark, removed from a point just above the hole. The resulting scar is used as a starting point for the next drilling operation. This habit is exactly like that of *O. nigricornis*, which differs from race B in its oviposition only in its decided preference for the upper side of a stalk.

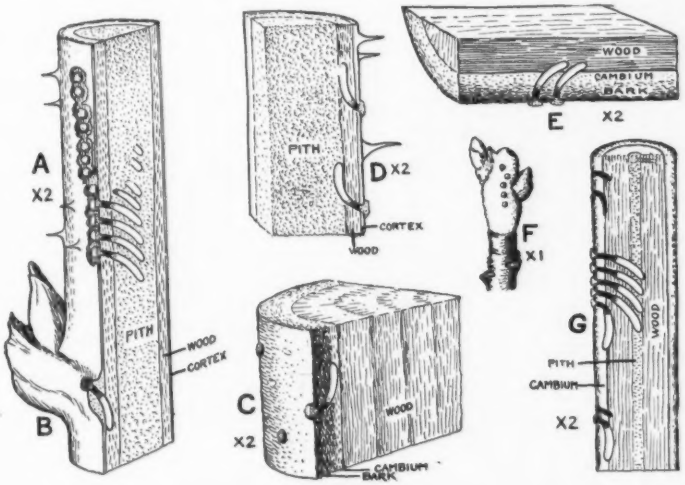

Fig. 1. Methods of oviposition used by varieties of *Oecanthus niveus*. A, Normal method of *O. niveus* B, and also *O. nigricornis*, in raspberry and other pithy plant stems. B, Normal method of *O. niveus* on raspberry in the eastern states. C, Normal method of *O. niveus* A on branches of trees. D, Forced oviposition of race A on blackberry, (Exp. A, 2). E, Forced oviposition of race B on apple branch. (Exp. B 10 and B 11). F, Oviposition of race B in green growth at tip of a side spur, when confined on an apple branch. (Exp. B 1 to B 5, Sept. 7). G, Oviposition of race B in hard watershoot of apple when given choice between that and a larger branch. (Exp. B 16).

The eggs of the two races of *O. niveus* in Oregon show no differences in the ornamentation of the cap at the cephalic end. Series of fifty of each kind showed slight relative differences in the total length and length of the cap. The average measurements in mm. are as follows: Race A, length, 3.16, width .67, length of cap .50, width of cap .52. Race B, length 3.01, width .68, length of cap .40, width of cap .52.

OVIPOSITION EXPERIMENTS WITH OECANTHUS NIVEUS, A.

Exper. No. of Female	Caged on September 9	September 14	September 22	October 24
A 1	Apple 14 mm. diam. Loganberry 6 mm. diam. (indoors)		25 eggs in apple. All placed singly in bark. No eggs on loganberry.	
A 2	Loganberry 3 mm. and 6 mm. diameter. (indoors)		24 eggs in larger cane, all imbedded in cortex and wood. Transferred to blackberry. 9 mm. diameter.	Cricket alive. 13 eggs all in cortex and wood.
A 3	Apple branch 20 mm. diameter with 2 small side spurs.	Several punctures observed.		Cricket dead. 14 eggs in bark, all but 2 on under side.
A 4	Loganberry cane close to ground.	No punctures on loganberry. Transferred to prune 20 mm. diameter.	Cricket alive. Punctures observed but not counted.	Cricket dead. 23 eggs deposited singly in bark. All but 4 on under side of branch.
A 5		Loganberry, 6 mm. diam.	Cricket alive.	Cricket dead. No eggs.
A 6		Loganberry, 7 mm. diam.	Cricket alive.	Cricket dead. No eggs.
A 7		Loganberry, 8 mm. diam.	Cricket alive.	Cricket dead. No eggs.
A 8		Grape, 5 mm. diam.	Cricket alive.	Cricket dead. No eggs.
A 9		On apple, watershoots. 5 and 8 mm. diam.	Cricket alive.	Cricket dead. No eggs.

OVIPOSITION EXPERIMENTS WITH OECANTHUS NIVEUS, B.

Exp. No. of Female	August 29	September 7	September 14	October 24
B 1, B 2, B 3, B 4, and B 5.	Apple branch 20 mm. diameter with small side spurs.	5 eggs in pith of green growth at tip of side spur. 2 incomplete punctures in large branch. Transf. to ornamental rose.	Row of 8 eggs in twig of 2–3 mm. diam. All in pith. 3 others in wood of larger twigs. Transf. to loganberry. 5–10 mm. diam.	Crickets dead. 95 eggs in 23 compact rows of 2 to 9 eggs. All but 8 in larger branch. All imbedded in pith.
B 6, B 7	Prune branch 20 mm. diameter. No side spurs.	No eggs. No punctures. Transf. to grape, 5 mm. diameter, present year's growth.	Compact row of 7 eggs, all slanting across pith. 7 incomplete punctures.	
B 8	Prune branch 16 mm. diameter. No side spurs.	No eggs. No punctures. Transf. to apple watershoots.	Crickets dead. No eggs.	
B 9	Prune branch 25 mm. diameter, with side spurs.	No eggs. No punctures. Transf. to loganberry.	Compact row of 10 eggs. All in pith.	
B10, B11		Apple branch 30 mm. diameter, with watershoot 4 mm. diameter.		Crickets dead. Row of 8 eggs in watershoot. Underside of large branch with 18 eggs.
B12, B13, B14		Wild rose, various sizes snowberry, 5 mm. diam. (indoors)	20 eggs in 3 mm. branch of wild rose. In 4 compact rows. All imbedded in pith.	
B 15		Apple branch 16 mm. diameter. Loganberry 6 mm. diam. (indoors)	(Sept. 22) 45 eggs in loganberry in 4 compact rows of 7, 9, 12 and 17 eggs. All imbedded in pith.	
B 16		1 apple branch 12 mm. diameter. With side spurs. (indoors)	(Sept. 22) No eggs. 4 incomplete punctures in spurs which had become dry. Trans. to apple branch 16 mm., watersprout, 6 mm.	Cricket dead. 22 eggs in sprout. Rows of 2, 4, 4, 8. Four single eggs in cambium. All imbedded in wood and pith.

Oviposition Experiments.

A series of experiments were carried out to determine the effect of transferring the two races from their normal host plants to those of the other form.

The insects were collected from pure stands of each race as determined by the character of vegetation, by the songs of the males and by the presence of eggs deposited in the characteristic manner. Race B was taken from loganberries and race A from apple, prune and oak trees. At the time the experiments were started the tree crickets had been mature about a month and had fully formed eggs in the body. All of them were fed on aphids during the experiments. They were caged on growing plants except where it is indicated that the experiment was performed indoors. The cages were made to surround a portion of a branch without cutting it off.

Notes on Oviposition Experiments.

A1. Of 25 eggs, all but two are directed upward from the puncture. Most of the holes are plugged with chewed bark, but some were plugged with excrement.

A2. On loganberry. Only four of the 24 eggs were placed at the side of leaf axils after the manner of *O. niveus* in the east, except that in these cases the eggs extended upward from the puncture. The other eggs were imbedded partly in cortex and partly in the underlying woody layer. Some of them reached the pith but none extended into it.

On blackberry.—Seven eggs and three empty punctures were found at leaf axils. Six eggs and numerous partially completed punctures were found in various other parts of the bark. The soft cortical layer was only about a half millimeter thick, so that most of the eggs were imbedded in the underlying woody layer, which was about a millimeter thick. Two eggs extended partly into the pith and one was almost entirely in the pith, but in these cases the eggs lay just under the woody layer and parallel to it, (Fig. 1, D), instead of slanting across the pith as when deposited by form B.

B1 to B5. In the first cage these females refused to oviposit in the large apple branch. A row of five eggs was found in the green terminal growth of a side spur, (Fig. 1, F).

The crickets were then confined on ornamental rose on twigs varying from 10 mm. in diameter to very small ones. Numerous attempts were made by the crickets to bore through the wood of the larger twigs, but apparently it was too hard for all the punctures terminated in the wood. Three eggs were found in holes which did not reach the pith. The only rows of eggs were in a small terminal twig; a row of five where the twig was 3 mm. in diameter and a row of three where it measured 2 mm.

After transfer to loganberry this same series of females deposited 95 eggs in the characteristic manner.

B10 and B11. These crickets were in a cage which included an apple branch 30 mm. in diameter and a small apple watershoot 4 mm. in diameter. Many attempts had been made to oviposit in the shoot, but few were successful. Most of the punctures were incomplete and terminated in the wood. There were two rows of 4 and 5 incomplete punctures besides several single ones. At the end of one of these rows, an egg had been deposited and toward the smaller end of the shoot there was a row of 8 eggs, all of which extended across the narrow pith. Apparently this watershoot was too hard for oviposition. The green tip was not included in the cage.

Twelve eggs were found in the bark on the underside of the large branch. These were placed in the usual slanting position with the distal ends imbedded in the wood. There were two sets of two placed one in front of the other about 1 mm. apart, as if forming an incomplete row, (Fig. 1, E).

B16. This female was given a choice of an apple branch of 16 mm. diameter and an apple watershoot of 6 mm. diameter. The 22 eggs were all placed in the shoot. All but four were imbedded in the wood and narrow pithy core. This wood was apparently almost too hard for the purpose and in six cases had turned the ovipositor so that the hole extended along the cambium layer parallel to the surface. In four of these holes eggs had been deposited and in such cases the position of the egg was like that of form A (Fig. 1, G). This was evidently due to force of circumstances and not from choice, but it shows that the habit of placing eggs singly in the bark could possibly have originated from the habit of placing them in rows in the pith. Of the four eggs mentioned, three were placed singly and the other was at the bottom of a row.

Summary of Oviposition Experiments.

Race A.

1. The females oviposited readily in the bark of prune and apple branches.

2. Females confined on grape and small apple shoots and most of those on loganberry canes, did not oviposit at all.

3. One female deposited eggs in loganberry and blackberry but in this case she placed the eggs in the cortex and woody layer in as near the normal manner as the physical character of the plant would permit, (Fig. 1, D).

Race B.

1. The females oviposited readily in loganberry and wild rose, placing the eggs in the pith in compact rows.

2. On ornamental rose, grape, and apple watershoots the same method of oviposition was used or attempted, but on these

plants the wood was a little too hard for drilling, as shown by the numerous partially completed punctures.

3. Four females confined on prune branches, (16–25 mm. diam.) did not oviposit at all. One of these was transferred to loganberry and it began oviposition on the following night.

4. Twelve eggs were deposited in the bark of an apple branch, where the only alternative was a watershoot which was too woody to be drilled into easily. The eggs did not lie nearly parallel to the surface as those of race A, but slanted at a forty-five degree angle and the distal ends were imbedded in the wood, (Fig. 1, E).

Song.

As mentioned before, the songs of the two forms of *Oecanthus niveus* in Oregon are very different. A more detailed study of the stridulation was made in order to make comparisons with the same species in the east.

The song of *O. niveus* has probably been written about more than that of any other American insect. By many writers it is considered the most musical of all insect sounds. It exhibits the interesting phenomenon of synchronism and has been much discussed in past numbers of the *American Naturalist* with reference to the relation between frequency of notes and temperature.

The stridulating organ of the tree cricket consists of a transverse vein near the base of the wing, which bears minute teeth on the underside. This is scraped by a thickening on the inner edge of the opposite wing. When the tree cricket sings it raises its wings perpendicularly over the back and vibrates them in a transverse direction. In the case of *Oecanthus niveus*, the vibrations are interrupted at regular intervals so that the song is a rhythmically repeated, whistling note.

Frequency of Notes and Temperature.

No study of the frequency of notes can be made without considering the temperature for the rate varies directly with the temperature. This relation of wing movement to temperature is present in all singing insects which the writer has observed, but only with those species whose song has a rhythmical beat, which is indefinitely repeated, can an accurate study of the correlation be made. In 1897, such a study was recorded by

Dolbear (7) who reduced the temperature correlation to an algebraic formula. He did not name the species of cricket but from his description of the song it was evident to later workers that he was dealing with the snowy tree cricket. A year later C. A. and E. A. Bessey (8), published a more detailed account with a graph made from a large number of records taken

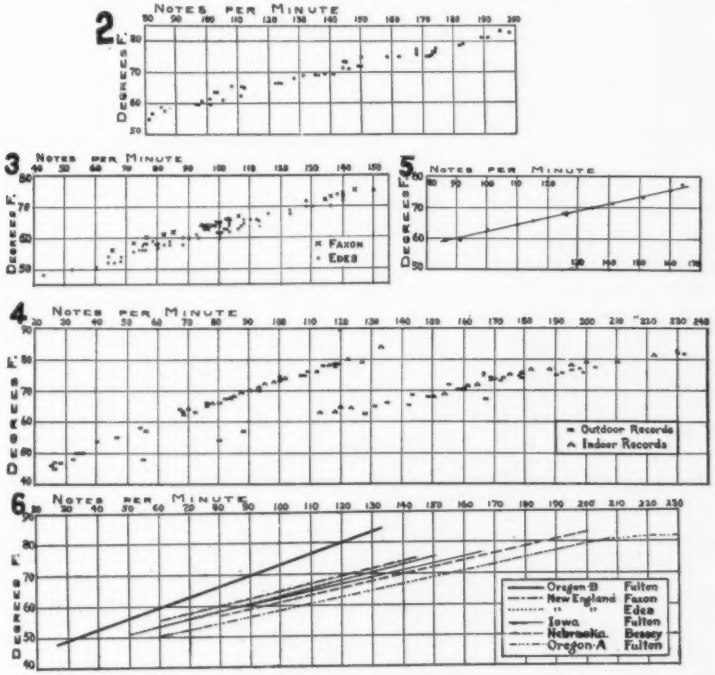

Fig. 2. Records of song of *O. niveus* taken by C. A. and E. A. Bessey in Nebraska.
Fig. 3. Records of song of *O. niveus* taken by Edes and Faxon in New England.
Fig. 4. Records of song of the two races of *O. niveus* in Oregon.
Fig. 5. Records of the song of one individual *O. niveus* taken indoors in Iowa.
Fig. 6. Comparison of graphs made from records shown in Figs. 2, 3, 4, and 5.

in Nebraska, (Fig. 2). Soon after that another article appeared by Edes (9) with a chart of observations made by himself and Faxon independently, (Fig. 3). Although both workers lived in New England the counts taken by the latter averaged a few notes less at the same temperatures. Edes states that his own

records might have been more accurate if the thermometer had been on the same side of the house as the bush in which the crickets were singing.

Comparison of the Song of *O. niveus* A and B.

Numerous observations at various temperatures on the songs of the two races of *O. niveus* in Oregon, both out-of-doors and in the laboratory, are recorded in Fig. 4. It can be seen from this that there is a wide range of difference between the songs of the two forms. For instance, at 70° F., race A stridulates at a rate of about 160 notes per minute, while race B has only 90 notes per minute. Such a difference as this can not be accounted for by any physical difference in the environment. Actual cage experiments show that the males of each form retain the same relative difference, regardless of surroundings. During several years of observation on these crickets, in many situations, I have never heard one which seemed to be intermediate between the two forms in regard to song.

Another slight difference in the method of singing was observed one night when the temperature had gone down to 48° F., which is near the lower limit of the singing range of the cricket. The slight quaver in the note, which is noticeable even at higher temperatures, was then so reduced in speed that the undulations of sound came no faster than I could count. In the case of race B, each note consisted of a series of four brief phases. This was observed for several individuals. By throwing a flashlight on the singing insect it could be plainly seen that the wings rubbed past each other four times for each note. In the case of race A the notes were noticeably shorter and observations on several individuals showed that this form made only three strokes of the wings per note.

Causes of Variation in Charted Data.

In charting the data on the song of the tree cricket, the points do not line up in a regular curve, but will be found scattered within rather narrow limits. In other words, all observations made at the same temperature do not agree. Shull (10), in attempting to find some factor other than temperature which might influence the frequency of notes, investigated the relation of wing length to rate of chirping and found no correlation.

He concluded that the variations were probably due to humidity, individuality and physiological state.

In my work on the tree cricket song I tried to discover some of the sources of error. An accurate thermometer should be used, preferably one with fractions of degrees marked. Records taken out of doors are not accurate for the reason that the temperature varies slightly from place to place and from time to time. In taking a record it is not possible to have the thermometer close to the cricket for it stops singing at a slight disturbance. I found that under the foliage of loganberries it was often a degree colder than just above if a slight breeze was blowing in the evening. The tops of apple trees would be sometimes two degrees warmer than near the ground. On one night the temperature was found to fluctuate over a range of nearly four degrees F. within a few minutes. In a rising or falling temperature there will be an error, for the temperature of the cricket will not rise or fall at the same rate as the thermometer.

Aside from error in temperature I believe that the greatest cause for irregularities in the song charts is slight individual variations. There is no doubt but that some males have a rate of stridulation slightly higher or lower than the average. I had one cricket confined in a cage in the house that was noticeably slower, about five notes per minute, than the others when it sang alone. When more than one cricket is singing in the same room, they assume a common rate and all sound their notes together in perfect harmony. The rate of such a chorus would depend to some extent on the individuals that composed it.

Fig. 5 shows a series of observations taken on one male cricket in a room. Records were taken only when the temperature was holding fairly constant. The bulb of the thermometer touched the side of the cage in which the cricket was confined. Each count was carried on for three consecutive minutes to avoid error in counting. Even in this case there is some fluctuation from a straight line, but it is much more regular than a chart of observations made out-of-doors on various individuals. It is possible that the element of fatigue may cause some variation in the frequency, but I have not had access to equipment necessary to determine this point.

Synchronism.

There seems to me no doubt about the synchronism in the song of the Snowy Tree-cricket, although it has been questioned by some, who claim that an auditory illusion is responsible for the belief that the notes of neighboring crickets are sounded simultaneously. As Allard (11) (12) has pointed out, there are other insects having an intermittent, rhythmical song which do not give such an effect, because they do not synchronize their notes. Not all of the Snowy Tree-crickets in an orchard or berry patch will have their notes perfectly synchronized, although on warm evenings there are times when the chorus seems to come very close to this condition. In a single tree or among any group of crickets that are not more than a few yards apart, the singers usually keep up a perfect synchronism. On very cool evenings, near the lower temperature range of stridulation, synchronism becomes imperfect or almost lacking. The phenomenon can be best observed with caged crickets indoors. When one male is singing and another begins the second one will make a few weak notes until it can catch the proper rhythm and then its notes sound simultaneously with the other.

Comparison of Song of *O. niveus* in the East and West.

If the graphs made from the stridulation records of the two races of *O. niveus* in Oregon are compared with those made by the Besseys and Edes, it can be seen that both forms differ from the same species in the east in regard to song, (Fig. 6). Also it can be seen that the Besseys' records, which were taken in Nebraska, differ slightly from those of Edes and Faxon, which were taken in New England. Barring errors by the use of a defective thermometer, it would appear that *O. niveus* in Nebraska sings faster than it does in New England and that race A in Oregon sings still faster.

Humidity.

One might suppose from this that the humidity of the air which in general increases from west to east during the summer, might be responsible for this difference. Shull (10) thought that humidity influenced the rate of chirping, but admitted that the evidence on the point was not conclusive. The writer has

one observation on this point. Two crickets were confined indoors where the temperature was kept fairly constant, one in a cage consisting of ordinary fly screen on all sides, and with no green plants inside, while the other was confined in a lamp chimney with a cotton plug in the top and many fresh green leaves inside. Moisture was condensed over the inside of the glass, showing that the atmosphere within was saturated.

The cricket in the lamp chimney did not chirp often, probably on account of the abnormal conditions in the cage, but on one occasion it sang for a time and its notes synchronized with those of the cricket in the wire cage. When each was permitted to sing alone, the rate was the same. The relative humidity of the air in the room was only 54% as determined by a sling psychrometer (dry bulb 66¾° F., wet bulb, 55¾° F.). This experiment was not tried on other crickets, but it shows that the effect of humidity on the rate of stridulation could at most not be greater than individual differences between crickets.

In the summer of 1923, the writer succeeded in taking to Oregon alive, two male crickets collected on apple in Ohio and two males collected on scrub oaks at Grand Canyon, Arizona. These were placed in separate cages in the same room with two males of the Oregon race A. When this lot was observed after dark, none of the usual synchronism of notes could be heard, but instead there was a confusion of sound, resulting from the crickets of each locality singing at somewhat different rates. One of the Arizona crickets was a most persistent singer and would be the first to start after they were stopped by a disturbance. An Ohio cricket would then apparently attempt to start in unison, but after a few notes would lose cadence and stop. After several such attempts it would sing independently at a somewhat slower rate. Counts of the three species taken within a half hour, with the temperature of the room holding close to 71° F., gave the following: Ohio 130, Arizona 140, Oregon A, 155.

This observation and the comparison of the song records taken by different workers in widely separated parts of the country, indicate that the average frequency of notes in the song of the Snowy Tree-cricket is not the same in all localities and that this variation is not dependent on the local physical conditions of the environment.

Crossing.

A male of race B was confined with a female of race A, and two males of A were confined with females of race B. Although these cages were examined frequently at night, no mating was observed for any of the three pairs. However, the cages could not be kept under constant observation and since few cases of mating were observed in the other cages where the sexes of the same race were confined together, it is entirely possible that crossing occurred. The females were already fertilized before capture. The writer had planned to start crossing experiments another year with immature crickets, but departure from the state prevented the carrying out of these plans.

Even if crossing did take place between individuals of the two races confined in a cage, it would not be a frequent occurence in nature because of the sharply limited ecological distribution. As stated before, the two races occur on the same plants only at the dividing line between deciduous forest or orchard and areas of low bushes.

Geographical Distribution.

Oecanthus niveus is the most widely distributed of all our native tree-crickets. It occurs over most of the North American continent from Maine, Ontario and British Columbia, southward. It is not common in southeastern U. S. and has never been recorded from Florida. It occurs in Cuba and is recorded from Guatemala and several widely separated points in Mexico. Besides having studied the species in New York and Oregon, the writer has made limited observations on its habits in Ohio, Iowa, Colorado and Arizona. The egg laying habits, both on trees and berry bushes, are essentially the same in New York, Ohio and Iowa. At the Grand Canyon, Arizona, the species was found living in junipers and small oaks, but no eggs were found. A few song records taken in Ohio agree with those taken by Edes and Faxon in New England. Records taken in Iowa, Colorado and Arizona occupy a middle ground near those taken by the Besseys in Nebraska. In no other place besides Oregon has the writer found any evidence of the existence of two races. It would be interesting to have for comparison some knowledge of the habits of the species in Cuba and Mexico.

The race A of *Oecanthus niveus* in Oregon does not differ greatly in song or egg laying habits from the same species in the east. Since the song of the species varies slightly in different parts of the country, it seems likely that there might also be slight geographical variations in other habits and that race A merges by gradual stages with the *O. niveus* of the central and eastern states.

Race B, however, is something more distinct. If its differences from the other form were morphological rather than physiological, it would constitute a separate species. It can be called a physiological variety. I have never observed it anywhere except in Oregon west of the Cascades. There it is widely distributed and is most abundant in the valleys, but is also found in burned areas in the Coast Range and lower Cascades. The race undoubtedly occurs also in western Washington, where conditions are practically identical to western Oregon. I believe that it also occurs in eastern Oregon and Washington in the Columbia and Snake River valleys. This assumption is based on tree-cricket eggs found at Walla Walla, Washington. They were in rather large wild rose bushes and were deposited in rows like the eggs of race B in western Oregon. They did not appear to be eggs of *O. argentinus*, which sometimes oviposits in small rose bushes, but usually in pithy weeds.

Other Examples of Physiological Varieties.

There have come to my attention, a few instances described in literature, of varieties of a species having a distinct difference in habits accompanied by slight or no morphological characters of separation. No doubt there are other cases scattered through the literature. I believe that a more intimate acquaintance with the habits of widely distributed species will show that such physiological varieties are not uncommon among insects.

I will describe briefly a few of the more striking examples. Howard (13) gave an interesting account of a fly, *Parexorista cheloniae*, which is parasitic on the Brown-tail Moth. The species exists both in America and Europe and is apparently identical in the two places, but the American race seems to be without defence against the poisonous barbed hairs of the caterpillar. The European race has become adapted to the Brown-tail physiologically and parasitizes it with impunity.

The European race was brought to America and colonized by thousands. It was found that they hybridized with the native race and after a few generations, with greatly diluted European blood, were no longer immune to the Brown-tail hairs.

Patch and Wood (14) have worked out the life history of the Blueberry Maggot, which is considered to be a small race of the ordinary apple maggot, *Rhagoletis pomonella*. There appears to be no difference between the two races except in size, but the food habits of the two are very distinct.

Among the Orthoptera, several instances have been described of varieties having a different song. Allard (15) states that "very marked differences of stridulation may characterize certain species in different parts of their range." He described differences in the song and other habits of the common field cricket, *Gryllus assimilis*, an extremely variable species morphologically. In New England, the song consists of intermittent chirps, while in northern Georgia a race occurs which has a prolonged, trilling note.

In the case of the Striped Ground Cricket, *Nemobius fasciatus* De Geer, also an extremely variable species, Allard (16) has discovered in Massachusetts two singing forms in the same locality, but having a different ecological distribution. One race occupies the dry, grassy upland fields and pastures and sings with a high pitched, prolonged trill. In damp marshy ground in fields and pastures, this race is replaced almost entirely by pure colonies of a form having brief intermittent notes. Only where wet and dry conditions overlap is there a noticeable intermingling of the two forms.

The writer has also found a race of the same species living on damp ground near Ames, Iowa, which appears to fit the description of Allard's intermittent singer. This was found only in grassy places near streams. An examination of a series taken from a pure colony of this form showed no characters to separate it from the common form. The song of the low ground race could be imitated by rubbing the edge of a fine-toothed comb lightly with the finger in short strokes. At 77° F. one of these crickets chirped from 24 to 30 times in ten seconds. There was no constant rhythm to the song and the frequency varied with different individuals, some chirping as much as 40 times in ten seconds. I watched a male singing and it appeared to make just one comparatively slow stroke of the wings per note.

Caged specimens of this race were observed to sing only in the manner described.

The song of the common form of *Nemobius fasciatus* is very different in quality and much louder. It has a very rapid wing movement and each stroke produces a sharp chirping note. The frequency is much faster than one can count at ordinary temperatures, and the song seems to be one prolonged note, having a distinct, tinkling quality.

At Mt. Pleasant, Iowa, in the southeastern part of the state, the writer found another differently singing variety of *N. fasciatus*, occuring in woods. This race was paler and more reddish in color than the common form, but some individuals of the pale color had the ordinary type of song. The song of this woodland variety differed only in the frequency of chirps which seemed to be just about half that of the common form. The notes were slow enough to be easily counted on cool days and even at higher temperature could be easily estimated by tapping a paper with a pencil in the same cadence and then counting the dots made in a certain period of time. At about 70° F. the frequency was close to five chirps per second. Male specimens of the woodland form, as well as the common form, were confined in separate cages with females. They always stridulated in their characteristic manner, but each form was found to have two songs. What might be termed the calling song was the one most commonly heard and is the song which I have described for each form. In it there was a constant cadence or rhythm which varied only with the temperature. When first starting to sing or when the male was actively courting the female, a slower frequency of chirps with less regular intervals, was used by each form, but the same comparative difference between the two forms was retained. At about 70° F., the common *N. fasciatus* would start chirping about 4 or 5 notes per second, but soon the speed would increase a little and then suddenly break into the regular tinkling song. The woodland form would chirp about twice per second in its preliminary song and then abruptly change to about five notes per second. If a female came near a calling mate, he would change to the slower song and follow her about with a nervous jerking of the body. At such times the song would be very irregular, varying both in loudness and frequency.

The woodland race of *N. fasciatus* was not found near Ames, nor was the lowland race found at Mt. Pleasant. In woods at Ames, only the song of the typical form was heard, as was also the case in low places along streams near Mt. Pleasant.

Summary and Conclusions.

1. Two races of *Oecanthus niveus* DeGeer are found in Oregon, which differ only in their habits. One form lives in bushes and the other in trees.

2. The habits of the tree inhabiting race differ but slightly from those of the same species in the eastern states.

3. The bush inhabiting form in Oregon is a distinct physiological variety.

4. The characteristic song and oviposition habits of the two forms of *Oecanthus niveus* in Oregon remain fixed when the adults of one form are confined to the normal environment of the other form.

5. The females of each form select plants for egg laying, which best meet the requirements of their characteristic mode of oviposition. This probably is the main factor in determining their ecological distribution.

6. The average frequency of notes in the song of *Oecanthus niveus*, at the same temperature, varies in different parts of the country. Slight individual variations in frequency occur in any one locality, but such differences are modified to synchronize the notes when more than one cricket is singing. Individuals brought together from certain widely separated parts of the continent find it difficult or impossible to synchronize the notes on account of the greater difference in frequency.

7. Physiological varieties of other species of insects have been recorded in literature. Among the Orthoptera, there are several species which have one or more varieties differing in type of song.

8. Three singing forms of *Nemobius fasciatus* are present in Iowa. The common form is found in all open fields and pastures. In the southeastern portion of the state, a different form is found in woodlands. In central Iowa a still different form occurs in low places.

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BOOK REVIEWS.

A General Textbook of Entomology. Including the Anatomy, Physiology, Development and Classification of Insects. By A. D. Imms, M. A., D. Sc., Chief Entomologist, Rothamsted Experimental Station. New York, E. P. Dutton and Co., Publishers.

The author of this important contribution to the literature of Entomology has attempted with a high degree of success to present a world wide survey of entomology in its different phases and while the student in any special field may not find all that he may wish on his particular subject, he will be able to secure a very comprehensive view of widely diverse branches.

The work is profusely illustrated with figures, many of which are new and many drawn from the works of well known authors. American students will find many of our familiar economic species treated in considerable detail, but will especially appreciate the bringing together of so large a mass of information concerning the important species of foreign lands.

H. O.

Anatomy and Physiology of the Honeybee. By R. E. Snodgrass. McGraw-Hill Book Company, 1925.

In this gem of morphological exposition Mr. Snodgrass has brought together all the main items of our present knowledge of the anatomy and physiology of the honeybee. The outstanding feature is the series of illustrations which are drawn in a boldness of contrasting white and black beyond the daring of an ordinary artist. Figures 70, 72, 74 and 75 are among the very best illustrations in morphological literature. With this gift of illustrative ability the volume shows Mr. Snodgrass' other ability of simple philosophical organization of the subject matter which gets the great amount of technical information across to the reader.

The subject is taken up in a series of chapters on the systems of organs and ends in two chapters on embryology and metamorphosis. The latter chapters, with that on the fat body and the oenocytes, are those most needed in present literature and are the high points in the whole presentation of the subject. The discussions of bee physiology give the reader practically all that is known on the subject and show how very little is really known positively on insect physiology. It shows that this is the great open field in Entomology which must be explored before this science can advance much farther.

C. H. K.

NOTES ON THE LARVAE OF THE CHALCIDOIDEA.

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I. Larval Types in the Chalcidoidea.

During recent years students of the biology of the parasitic Hymenoptera have made several attempts to classify the larvæ of these insects in groups based on certain striking features of the external anatomy. Thus Richardson ('13) in his paper on Spalangia, and Wheeler ('23) in her account of the braconid parasites of aphids, distinguish respectively 9 and 10 types of hymenopterous larvæ distributed among the several parasitic families. Up to the present, however, so far as the writers are aware, no efforts have been made to define such larval types within the individual superfamilies of the parasitic Hymenoptera, although in almost every group a considerable number of larvæ have been described.

Extensive investigations of the larvæ of the Chalcidoidea, the results of which will be published at an early date in detail, taken together with the data previously available, have demonstrated the existence within the superfamily Chalcidoidea of a number of well defined larval types. As is the case in most of the other groups, these types are readily recognizable only in the primary larvæ; in the later stages the morphological differences become much less apparent.

The ectophagous larvæ of the Pteromalidæ and certain Callimomidæ (Torymidæ), Eulophidæ, and Elasmidæ (Dibrachys, Spalangia, Pseudocatolaccus, Pachycrepoideus, Pachyneuron, Mormoniella, Megastigmus, Ormyrus, Melittobia, Solenotus, Eulophus, Tetrastichus, Perissopterus, Elasmus) (Fig. 2) present a head and thirteen well developed segments, both head and body being feebly chitinized and unpigmented; the head capsule bears a number of relatively short sensorial hairs or papillæ, and one pair of short conical truncate antennæ; the mandibles are gently curved; the body segments under low

magnifications appear glabrous, though a careful examination with a high power objective will reveal the presence on each segment of an anterior band of minute spines together with two or three pairs of very small sensorial hairs; in this stage the tracheal system presents four pairs of open spiracles situated on segments II, IV, V, and VI.

The ectophagous larvæ of the Callimomidæ (in part) Eupelmidæ, Leucospidæ, and Eurytomidæ (Callimome, Ditropinotus, Eurytoma, Eupelmus, Cerambycobius, Leucospis) (Fig. 5) possess also a well developed head followed by thirteen segments; the body is feebly chitinized and unpigmented, but the head is brown in color and strongly chitinized; the mandibles are more powerful than in the first group mentioned and are more strongly curved, being approximately comma-shaped; each body segment presents two or three pairs of long sensory hairs easily visible under the low powers of the microscope, or even under a hand lens; in addition each segment bears a median or submedian girdle of large and conspicuous cuticular spines; these larvæ, like those of the previous group, bear four pairs of open spiracles.

The sexual larvæ of the polyembryonic chalcids, all of which belong to the family Encyrtidæ (Copidosoma, Litomastix, Encyrtus) (Fig. 1) constitute another well characterized group. The external anatomy here is extremely simply; no spines or sensoria are present; the mandibles are very feeble, poorly developed, and practically invisible; the tracheal system is closed.

Another group of very curious and interesting first stage larvæ also found in the Encyrtidæ and represented by the Genera Microterys, Blastothrix, Schedius, Phænodiscus (Fig. 3) and certain species of the genus Encyrtus, (e. g. (Encyrtus) *Microterys ferrugineus* Nees) are those which are attached to the outer wall of the host (or egg shell in the case of Schedius, parasite in the eggs of *P. dispar*) by means of the eggshell of the parasite itself. The pedicel of the chalcid egg transverses the body wall of the host, and in some cases it is hollow and appears to act as a respiratory tube, comparable to the integumental and tracheal sheaths of the dipterous parasites of insects. The bodies of these larvæ are composed of a head and ten segments instead of a head and thirteen usually present in chalcid larvæ.

This difference is due in all probability to the fusion of the last four segments during the embryonic development but in the later stages these segments are clearly differentiated. Most of the individuals of this group are metapneustic, like first-stage tachinid larvæ, possessing only a single pair of open spiracles situated on the posterior extremity. Many larvæ of this type have been described by Silvestri.

Still another group presenting well-defined morphological characters is constituted by the primary larvæ known as "planidia" (Fig. 6) in which the dorsal surface of the head and body segments is heavily pigmented and strongly chitinized, so that the larvæ resemble miniature armadillos. All of the larvæ of this group which have been identified up to the present belong to the genera Orasema, Perilampus, Psilogaster, Schizaspidia, and Stilbula, included in the families Perilampidæ and Eucharidæ. In the perilampid larvae so far known the body is composed of twelve segments in addition to the head, while in the eucharids the head is followed by eight segments in the genera Schizaspidia and Stilbula, with eleven in Psilogaster. All these larvæ, with the exception of Schizaspidia, bear numerous spines, varying in disposition, and which probably are ambulatory in function. They likewise bear a limited number of sensory setæ. They are very active, although not more so than are those of the Torymidæ, Eupelmidæ, Eurythomidæ, and Leucospidæ in their more restricted environments. These larvæ are extremely interesting on account of their varying parasitic habits and modes of existence.

As already stated, all of the groups just mentioned, with the exception of the two forms of Encyrtidæ, are composed of ectophagous parasites; the Encyrtidæ are, while endophagous, either attached to the body wall or are enclosed in the epithelial cyst characteristic of the polyembryonic forms.

There are, however, a certin number of endophagous forms which float freely in the body cavity of the host egg, larva, or pupa. These larvæ in most cases are strikingly different from even their nearest relatives, systematically speaking, in that they possess a more or less elongate caudal appendage or tail. The only free-living internal chalcid larvæ not of the caudate type are those of *Pteromalus puparum* L., the common parasite of lepidopterous chrysalids, and a species of Miscogaster, par-

asite in an agromyzid larva. The former, except for the fact that it is apneustic, does not differ from the ectophagus forms such as *Dibrachys boucheanus* Ratz., etc. The latter, whose anatomy is rather remarkable, will be described later in this paper.

The various members of the group of caudate larvæ (Fig. 4) have much in common anatomically, often being almost exactly alike in construction although widely separated systematically. Larvæ which have already been studied can usually be identified specifically when subsequently encountered, but an unknown larva of this group cannot at present be referred with certainty even to its family on morphological characters alone. Such a larva might be a tetrastichine, a chalcid, an encyrtid, or an aphelinid.

The known larvæ of this type belong to the following species: *Cerapterocerus mirabilis* Westw. (Encyrtidæ); (*Chalcis Brachymeria fonscolombei* Duf. (Chalcidæ); *Tetrastichus xanthomelænæ* Rond., and *Aspidiotiphagus citrinus* Craw. (Eulophidæ); *Copidosoma thompsonii* Mercet (n. sp. in litt.) and *C. boucheanum* Ratz. (Encyrtidæ)—a sexual larva only; and *Anastatus sp.* (Eupelmidæ). They are characterized principally by the presence of a caudal appendage, usually of very simple form, though in the case of *T. xanthomelænæ* and *Anastatus* it is bifurcate; the head is longer than wide, somewhat pointed anteriorly, and bears two strongly uncinnate mandibles; the cephalic sensoria are mostly inconspicuous and few in number. The body is distinctly segmented and generally armed with cuticular spines, true sensorial hairs, however, appearing to be usually lacking or at least very poorly developed. All the larvæ of this group heretofore described are apneustic in the first instar.

In view of the relative morphological uniformity presented by the free-living endophagous chalcid larvæ, it seems interesting to record the existence of a transitional type between these larvæ and the ectophagus forms of the second group described above. This transitional form is represented by the larva of Anastatus sp., which in this stage, is an internal parasite in the egg of an undetermined pentatomid.*

*The eggs of the pentatomid from which this parasite was reared were collected on the bark of fig trees at Puget-Ville, Var, France, by P. Genieys of the European Parasite Laboratory, in June, 1924.

II. Two New Forms of Caudate Chalcid Larvae.

Anastatus sp.* (Eupelmidæ).

Unlike the endophagous forms mentioned above, the first-stage Anastatus larva resembles fairly closely in its morphological characters the primary larvæ of the species to which it is systematically related; i. e., the species comprised in the families Callimomidæ, Eurytomidæ, Eupelmidæ, and Leucospidæ. Like the other members of this group, the larva of Anastatus bears on the head and body segments numerous elongate conspicuous sensorial hairs; the cuticular spines on the body segments are arranged in definite dorsal and ventral areas, much as in Callimome, Eupelmus, Leucospis, and Eurytoma. The head is brownish in color and heavily chitinized and the body bears four pairs of open spiracles. By certain other characters, however, this larva resembles the members of the small heterogeneous group of caudate larvæ. Like these latter it possesses a well developed "tail," in this case bifurcate. Only two pairs of cephalic sensorial hairs exist, as against 6 or 8 in the larvæ of Callimome, Eupelmus, Eurytoma, and Leucospis.

In view of these peculiar characteristics one might be tempted to consider the larva of Anastatus as a form which has recently adopted the habit of endophagous parasitism and whose morphology is now undergoing the changes which lead from the ectophagous to the endophagous type; at present, however, no convincing reasons in favor of such a hypothesis really exist.

The morphological characters of the species of Anastatus here considered are as follows:

Egg.

Length of egg, 0.4 mm.; length of pedicel, 0.4 mm. (Fig. 18). Color, white; approximately oval in shape; without armament or tubercles; provided at one end with a short, slightly twisted pedicel, at the other end with a long pedicel.

First-Stage Larva.

Length, 0.6 mm.; width, 0.15 mm. (Fig. 7).

Cylindrical, segmented, slender; head brown, heavily chitinized; body white, provided with a bifurcate caudal appendage; body segments bearing long sensory setae and many shorter cuticular spines.

*Determined by Dr. Luigi Masi, who says "L'espece que vous avez obtenu des oeufs d'un hemiptere ressemble a celles decrit par Bolivar sous le nom de *A. bifasciatus* Fonscol. et parasite du lepidoptere Dendrolimus pini "

The head (Fig. 17) is somewhat thimble-shaped, a little drawn out at the anterior end, and slightly bent ventrally; it is strongly chitinized and brownish in color, and bears a pair of prominent bristle-like setae situated anteriorly and somewhat laterally, although above the lateral line; another pair of setae is situated ventrally and towards the anterior portion of the head; the mouth is located at the extreme anterior end of the head and is a small circular opening in the middle of the unchitinized buccal area; the mandibles are simple, sharp, and comma-shaped, black distally, lighter in color toward the base; there are four pairs of sensory organs on the upper lip and three pairs on the lower; the tentorium, or inner skeleton of the head, can be seen from the ventral surface and is, in form, approximately horseshoe-shaped.

The body segments are thirteen in number, distinctly delineated, approximately equal in length, but those near the anterior end are distinctly wider than are those of the posterior end, as the figure shows (Fig. 7); the thoracic segments each present three pairs of prominent sensory hairs disposed as indicated in the drawing, the second and third in addition present cuticular spines located as follows: a small area dorsally situated near the anterior margin, and a somewhat more extensive area located ventrally toward the anterior margin; the spines in the dorsal area are short and stout, while those in the ventral areas are considerably longer; the abdominal segments present but two pairs of sensory hairs each, situated one pair about on the lateral line, the other pair more dorsally; these segments are likewise armed with tegumentary spines, those of the dorsal area becoming longer on the posterior segments; progressively from segment to segment posteriorly the cuticular spines become more abundant and the sensory hairs diminish in size so that they are not readily distinguishable from the cuticular spines; we believe, however, that there are two pairs on each of the first nine abdominal segments; the last segment is adorned with a bifurcate caudal process which bears on each prong near the base smaller spines identical in shape with those found on the more forward portion of the segment. (Fig. 19).

The tracheal system is well developed; there are four pairs of open spiracles situated on the second thoracic and first to third abdominal segments inclusive; each spiracle is connected by its canal to the main tracheal trunk that passes down the side of the larva. These main tracheal trunks are joined together anteriorly by a tracheal commissure traversing the body dorsally of the oesophagus in the first thoracic segment, and posteriorly by a like commissure passing ventrally of the hind intestine in the eighth abdominal segment; in each segment, from the first thoracic to the eighth abdominal, the main tracheal trunk gives off several fine, ramifying branches which distribute themselves dorsally and ventrally in the body cavity among the several organs and tissues.

Changes in External Characters During Development.

When the larva sheds its first skin it loses its brown, heavily-chitinized head capsule, its tegumentary spines, its bifurcated tail appendage, and its long sensorial hairs; the head becomes more spherical (Fig. 8) and white in color, less heavily chitinized than before; the body becomes wider and shorter in proportion owing to the absorption of food, and, save for the minute sensoria where once the long hairs existed, it is naked; five additional paris of spiracles appear. Such changes have often been noted in part by students of the Perilampidæ, the Eucharidæ, the Braconidæ, and other parasitic hymenoptera (and indeed to go further, analagous changes are well known in the Coleoptera, the Diptera (tachinids), the Strepsiptera, and even among certain groups of parasitic marine Crustacea (Cryptoniscidæ). Spines and teeth which are purely tegumentary are lost with the molted skin; sensorial organs, whether they be bristles, hairs, roundish disk-like, or conical processes, are always retained throughout the life of the larva; they are often indeed generally reduced in size but they can be located by a careful examination.*

The full-grown larva of this species is short, thick, and grublike in general appearance, similar to that figured by Howard and Fiske ('11) from eggs of the gipsy moth.

*A striking example of this is to be seen in the later stage larvae of Perilampus. These planidia bear slender setae arranged in pairs on the heavily chitinized dorsal plates. After the hard skin of the first-stage larva has been shed one may still see on the now fleshy larva (at points homologous with those which formerly bore the setae) a tiny button bearing at its summit a fine short seta which exists throughout the life of the larva, and which persists on the last larval skin when this is thrown off by the pupa. A variation on this scheme is to be observed in the case of certain Callimomids notably in the genera Callimome and Ditropinotus. In this case the second stage sensorial hairs, though somewhat reduced in size, are not inconspicuous. As the larva grows and changes its skin their relative length increases until at the last stage such hairs are as conspicuous and as long in proportion to the size of the larva as they were during the first stage. Furthermore, in the last stage of these larvae, there exist, especially on the ventral surface, many long brownish setae similar in every way to the sensorial hairs, though whether they be sensorial in function or simply tegumentary hairs has not yet been determined. Again, the larva of Podagrion (Callimomidae), parasite upon the eggs of the mantid, *M. religiosa*, commences life deprived of conspicuous setae or spines but at the last stage the body as well as the top of the head, is practically covered with brownish hairs of a moderate length. The well-known hornlike processes on the head of *Perilampus hyalinus* Say (primary larva) serve as another example. These two pairs of organs are lateral sensorial organs and are the homologues of similar sensoria found on the heads of other chalcid larvae; they exist on the second-stage larva in a somewhat diminished state at a point near the lateral edges of the chitinous portion of the head where it gives place to the soft buccal region.

Miscogaster sp.* (Miscogasteridæ).

This chalcid is parasitic internally in the larva of a species of *Agromyza* (Diptera) mining in the leaves of alfalfa at Hyeres, Var, (France). The adults are found in the fields rather early in the spring, and deposit their eggs through the surface of the leaf into the body cavity of the host larva. A certain proportion of the parasites appear to emerge in late spring, producing another generation, but the majority seem to remain in the puparia of the host until the following spring (or in any event throughout the entire summer, as we have on hand at the moment of writing—October 10—a considerable number of unissued parasites appearing to be in the pupal stage). The presence of the parasite larva in the host larva does not prevent it from forming its puparium. The adult parasite issues through an opening which it makes with its mandibles in the puparial wall. From one to six eggs may be deposited in a single host larva, but only one parasite comes to maturity.

The morphological characters of the species are as follows:

Egg.

Length, 0.25 mm.; width, 0.12 mm. (Fig. 15).

When taken from the body of the host the egg of this species is blackish in color and apparently rather heavily chitinized. It is roughly oval in form and is attached to the body wall of the host by a rather thin pedicel which is about half of the length of the egg proper. This pedicel protrudes outside the host cuticle for a short distance, but does not seem to be aeroscopic in function, nor does it retain the parasite larva after hatching, for this larva floats freely in the body cavity of the host.

First-Stage Larva.

Length, 0.55 mm.; width, 0.175 mm. (Figs. 13, 14).

Rather slender; white in color, possessing a head and thirteen segments; no conspicuous caudal appendage, but a last segment of bilobed appearance terminating in two rather large spines; sides of body segments ornamented with long cuticular spines arranged in an encircling line at about the mid-portion.

Head (Fig. 16) slightly wider than long, in color white, not especially strongly chitinized, bearing a pair of short button-like antennae, but no conspicuous sensorial hairs; it is roughly conical in shape but rounded at the anterior end; ventrally can be observed three pairs of sensory circles, situated along either side of the buccal area, while on the upper lip are two small pairs of similar sensoria; the mandibles are brownish in color, long, sharp, but not greatly hooked; the tentorium is visible and is semicircular in form.

* Determined by Dr. Luigi Masi.

The body is widest at the first thoracic segment, tapering gently caudad; the segments all bear, on the pleural region, a line of rather long cuticular spines, situated on the middle of the segment; those of the first segment are less numerous and shorter than those which appear on the middle of the body; the exact nature of the terminal segment is rather difficult to discern; viewed from the ventral surface it appears to be bilobed; each lobe seems to terminate in a stout spine apparently differing from the many surrounding spines in being longer and wider at the base; these two spines are analogous to the posterior processes in certain forms of caudate larvae. This larva thus conforms to the general type of the group of internal parasitic free-living forms found scattered among the Chalcidae.

III. The Primary Larva of *Stilbula cynipiformis* Rossi (Eucharidae).

All of the members of the family Eucharidæ whose habits are known are parasitic in the larval condition on ants. Until recently, if we except Wheeler's well known study on *Orasema viridis* Ashm. in his paper on "The Polymorphism of Ants, etc." ('07) and the later contribution on *Psilogaster fasciventris* Brues. by Brues ('19), very little detailed information has been available as to the habits of this family. In 1923 a most interesting and very complete paper on the biology of the Japanese eucharid *Schizaspidia tenuicornis* Ashm. was published by C. P. Clausen.

According to Clausen, *S. tenuicornis* is a parasite in the larval stage upon the pupa of the ant *Camponotus herculaneus* in Japan. The adults issue from the ants' nests during August and mate, and the females are ready to oviposit at once; this they do in the buds of several trees and bushes, notably mulberry, chestnut, etc.; each female oviposits from a thousand to twelve hundred eggs all in one batch in the bud of the host plant. The larvæ mature in the eggs, remain there all winter, and hatch during the following spring; they then attach themselves to the feet of passing ants and are transported to the ants' nests where they release the ants and fix themselves to the ant larvæ, feeding and later completing their development on the ant pupæ.

The egg of *S. tenuicornis* is tiny, oval in shape, white in color, and bears a long filiform appendage on one end. The first-stage larva is dark in color, composed of heavily chitinized rings, and has a head and eight body segments; the head and segments apparently bear neither true setae nor cuticular sensoria, but the fifth, sixth, and seventh segments each bear

one pair of stout spines laterally, while the eighth bears two pairs; the larva possesses two small hooked mandibles. This larva is an excellent example of the planidium type.

Some years ago the writers discovered in the valley of the Gapeau river at Montrieux (Var, France) a colony of adults of the European eucharid *Stilbula cynipiformis* Rossi, the biology of which had apparently never been investigated. On August 27, 1923, about twenty-five specimens of the adults were collected from oak bushes and brought alive to the laboratory, where they were placed in cages. By the end of the third day all of the individuals taken were dead without having fed. The females paid no attention to oak leaves or to ant cocoons placed in the cages with them; the possibility of their ovipositing in buds did not occur to us at that time; dissection of the females showed the forty ovarian tubes of the reproductive system to contain a thousand or more eggs apparently ready to be deposited. These eggs, like those of Schizaspidia, were very minute, oval in shape, white in color, and bore a long filiform appendage at one end. (Fig. 9-a).

The following spring, on June 11, about five hundred cocoons of Camponotus were collected in the vicinity. During the month of August following there issued two adult Stilbula from these cocoons. An examination of one of the cocoons showed that the cap had been neatly and smoothly cut off to allow for the emergence of the Stilbula; that the inside of the cocoon was filled with the cast larval and pupal skins of the parasite, and that the remains of the ant, apparently a newly formed pupa, were reduced to a small, irregular, hardened mass of material and pushed down into the opposite end of the cocoon from which the parasite had issued.

By cautious manipulation the skin of the first-stage larva was located. It was attached to a bit of membrane which we believe to be a part of the last larval skin of the Stilbula; the head had become separated from the body, and the segments themselves were widely separated one from the other; they retained, however, their relative positions. The figure drawn from the preparation of this moulted skin (Fig. 9) will give some idea as to the original form of the primary larva of Stilbula.

The head (Fig. 10) is dark in color and more or less rectangular in shape and apparently bears no sensoria or setae; apart from the internal circular opening of the salivary duct common

to all chalcid larvae, we are able to distinguish nothing save a pair of sharp brownish mandibles of the usual comma shape.

The segments are eight in number, all dark in color, being heavily chitinized; the first one is twice as wide as long and bears two pairs of filiform setae situated in light colored circles; the second is four times as wide as long and bears one pair of setae; the following segments are about equal in length, the fourth bearing a pair of setae, while the fifth, sixth, and seventh bear laterally a pair of stout spines at the posterior margin; the eighth bears two pairs on each side and terminates in a bifurcate median spine. The ventral terminations of the chitinous rings were not visible in our preparation.

On a morsel of skin we believed to be a part of the second-stage larval skin, we are able to distinguish irregular rows of fine tegumentary spines (Fig. 11) probably situated on the anterior margin of each segment; these structures probably are analogous to the spines found on the second-stage larva of Perilampus; in addition, on this piece of tegument are visible two spiracles, one of which we have illustrated, (Fig. 12). The condition of the remains is not such as to enable us to state whether the adult larva possesses mandibles.

The several points in which Stilbula resembles Schizaspidia are: the shape of the egg; the morphology of the primary larva; the period of emergence of the adults and brevity of the adult life; the remarkable fecundity of the female; and the probability that the eggs are all deposited in a single batch—indicated by the condition of the female ovaries. These resemblances would seem to indicate that the life history of Stilbula is very similar to that of Schizaspidia. It is hoped that a further investigation which we intend to make next season will permit us to verify this conclusion and clear up the obscurities in the biology of this interesting parasite.

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EXPLANATION OF PLATES.

PLATE XXVI

Fig. 1. First stage larva of Copidosoma thompsonii Mercet in lit. removed from its envelope in the developing chain. This design represents the larvae of Group III*; Polyembryonic encyrtids, Copidosoma and Litomastix.

Fig. 2. First stage larva of *Dibrachys boucheanus* Ratz. Representing larvae of Group II Dibrachys, Spalangia, Pseudocatalaccus, Pachycrepoideus, Pachyneuron, Mormoniella, Megastigmus, Ormyrus, Melittobia, Solenotus, Eulophus, Tetrastichus (ectophagous Tetrastichines) Perissopterus, Elasmus.

Fig. 3. First stage larva of (*Encyrtus*) -*Microterys ferrugineus* Nees. Representing larvae of Group IV: Microterys, Phaenodiscus, Encyrtus, Aphycus, Blastothrix.

Fig. 4. First stage larva of (Chalcis) *Brachymeria fonscolombei* Duf. Representing larvae of Group V: (Chalcis) Brachymeria, Cerapterocerus, Aspidiotiphagus, Tetrastichus (T. xanthomelaenae), Anastatus, and Miscogaster.

Fig. 5. First stage larva of Callimome (Torymus) sp. (near *C. phyllyreae* Rush.). Representing larvae of Group VI: Callimome (Torymus), Ditropinotus, Eurotoma, Eupelmus, Cerambycobius, Leucospis. The tracheal system is not shown in this drawing, but it is identical with that of Fig. 2.

Fig. 6. First stage larva of *Perilampus hyalinus* Say. Representing larvae of Group VII: Perilampus, Psilogaster, Schizaspidia, and Stilbula. The two circular spots on segment II are the only open spiracles on this larva, on the others mentioned in this group there are apparently none.

PLATE XXVII

Fig. 7. First stage larva of *Anastatus bifasciatus* (Fonsc) Bolivar.

Fig. 8. Second stage larva of same.

Fig. 9. The several segments comprising the first stage larva of *Stilbula cynipiformis* Rossi. drawn in situ from the cast larval skin.

Fig. 9-a. Egg of same taken from ♀.

Fig. 10. Head capsule of same viewed from the ventral surface.

Fig. 11. Minute spines found on second (?) stage larval skin, *S. cynipiformis*.

Fig. 12. A spiracle of same drawn from second (?) stage larval skin.

PLATE XXVIII

Fig. 13. First stage larva of Miscogaster sp., viewed from the ventral surface.

Fig. 14. Same viewed from the side (slightly more enlarged).

Fig. 15. Egg of same.

Fig. 16. Head of same ventral view.

Fig. 17. Head of first stage larva of *Anastatus bifasciatus*.

Fig. 18. Egg of same.

Fig. 19. Last segment of first stage larva of *A. bifasciatus* viewed from ventral surface showing bifurcate caudal appendage.

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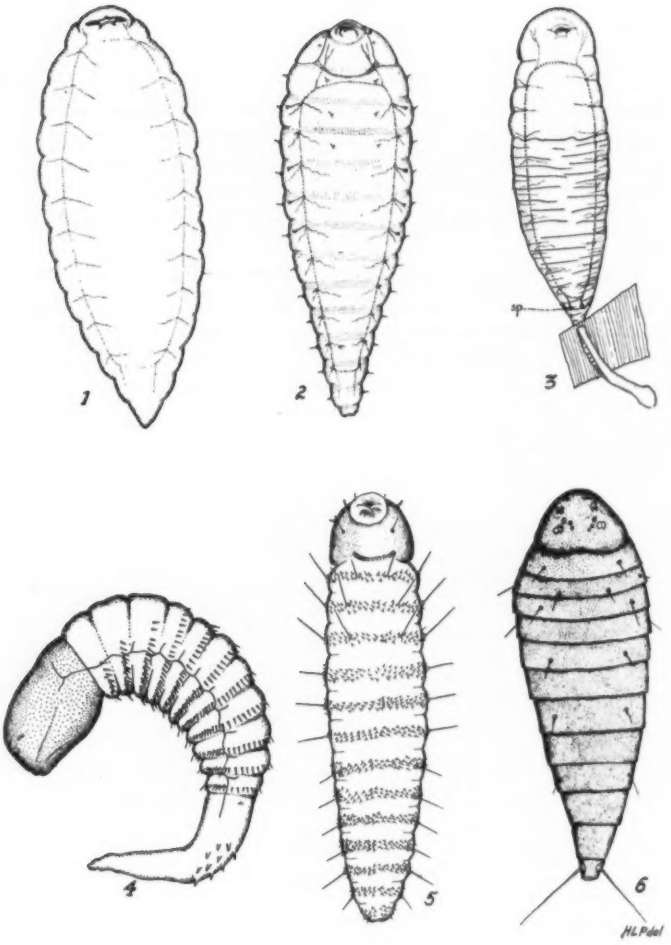
* The arbitrary numbering of these groups has no significance here.



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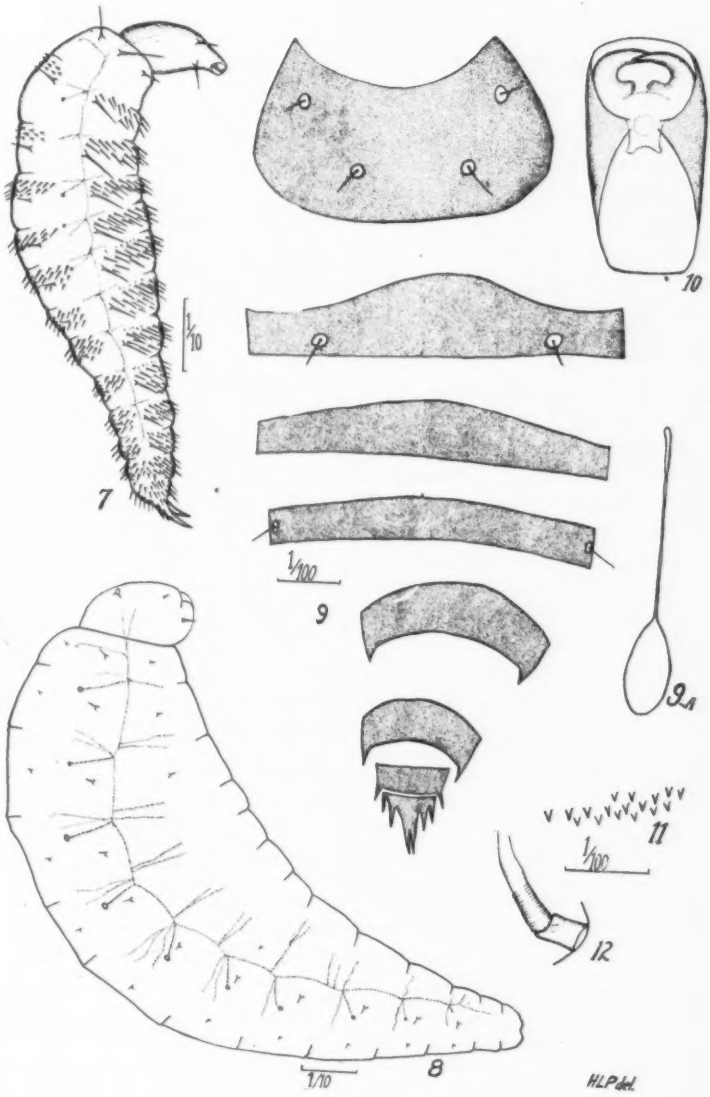

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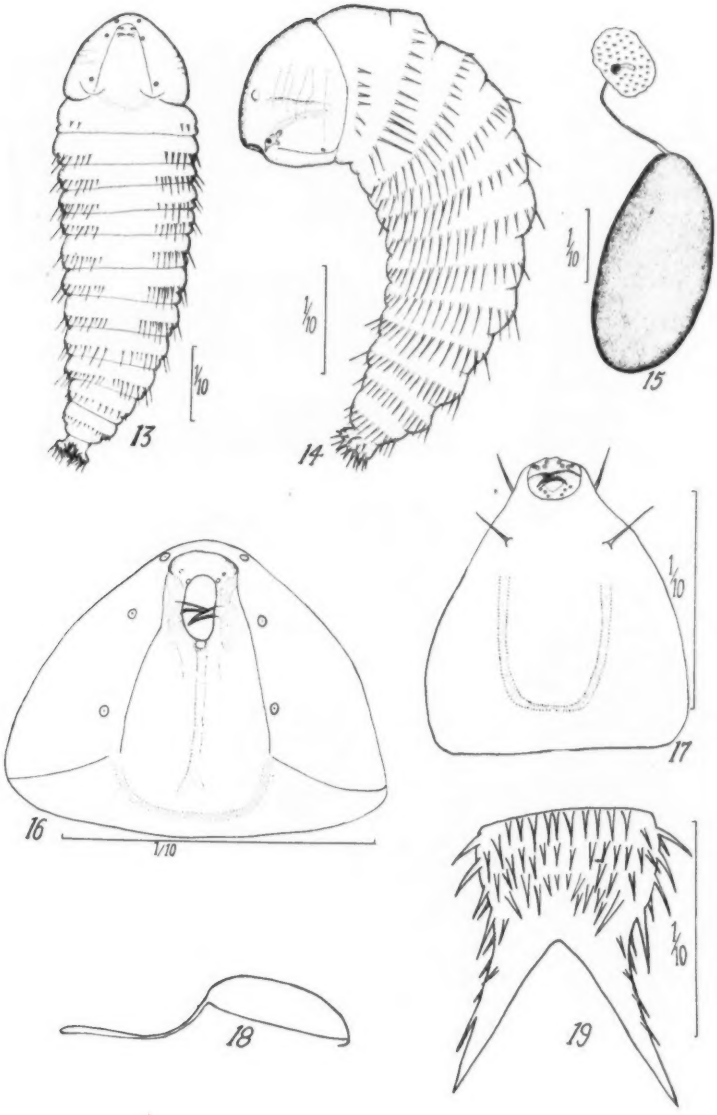

Parker and Thompson

THE LEAF-MINING HABIT IN THE HYMENOPTERA.

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Our knowledge of the leaf-mining habit in the Hymenoptera dates back to De Geer (1752). Although Reaumur (1737) and Swammerdam (1758) speak of the leaf-mining habit, they make no mention of the Hymenoptera. Since the time of De Geer, several comprehensive papers have appeared, dealing wholly or in part with the leaf-mining Hymenoptera. These are classics and are worthy of mention. The work of Brischke (1880) "Die Blattminirer in Danzig's Umgebung," although devoted largely to Lepidoptera and Diptera, has numerous references to leaf-mining Hymenoptera. Three years later Brischke and Zaddach (1883) published a valuable paper on leaf and wood-boring wasps, containing many original food records and excellent plates of the larvae and their mines. Linnaniemi (1913) in his "Zur Kenntnis der Blattminirer," refers briefly to the leaf-mining Hymenoptera. Many papers, too numerous to mention here, have appeared during the last fifty years in American literature, dealing with the life histories of individual species. In passing, reference should be made to certain systematic papers as Konow (1901–02), Enslin (1914–17), Yuasa (1922) and the numerous writings of Rohwer and MacGillivray, especially the synopsis of the American species of Scolioneura, MacGillivray (1909) and the classification of the Chalastogastra by Rohwer (1911).

ORIGIN OF THE LEAF-MINING HABIT.

The leaf-mining habit is apparently ancient in the Hymenoptera. This may be considered from two points of view. First, the habit is ancient as compared with the same habit in other orders. Second, it is well established within the order Hymenoptera with no evidence of recent origin. The following table with summaries of the leaf-mining families and their outstanding habits, will aid in comparing the leaf-mining habit in the Hymenoptera with the mining habit in the other orders.

The leaf-mining habit is undoubtedly more ancient, or at least better established in the Hymenoptera than in the other three orders. This is evident because the habit occurs but a few times in a comparatively small group, and is not scattered throughout the order. There is no indication that species exist in the process of adapting themselves to the mining habit. The blotch type of mine, uniformly present throughout the order and the highly specialized larvae are indications that the habit is well established in the Hymenoptera. On the other

A Comparison of the Orders of Insects in Respect to the Mining Habit.

	Hymenoptera	Lepidoptera	Coleoptera	Diptera
Families	Tenthredinidæ	At least 18 families widely scattered in the microlepidoptera	Buprestidæ Chrysomelidæ Curculionidæ	Tipulidæ Cecidomyiidæ Trypetidæ Agromyzidæ Drosophilidæ Ephydridæ Anthomyiidæ Cordyluridæ
Type of mine	Blotch	Linear and blotch	Some linear, chiefly blotch	Linear and blotch
Larva	Highly specialized	Highly specialized	In Chrysomelidæ and Curculionidæ not greatly different from others of the same group.	Not greatly different from others of the same group.

hand, there is little doubt that the leaf-mining habit in the Diptera is rather recent. This was pointed out by the writer (1924) by reference to certain species that are in the process of adapting themselves to the leaf-mining habit.

Some species of Lepidoptera, likewise, have not become completely established in their mining habits. Certain species, for example, mine in a leaf, work their way down the petiole, thence into the twig, mining as bast miners or as twig miners and again return to the leaf. Such unsettled habits have not been found in the Hymenoptera. All of the species, as far as the writer knows, possess a mining habit with no tendency to the gall-making or boring habit.

In considering the Coleoptera and the Lepidoptera, it is difficult to say in which the leaf-mining habit is more ancient. The highly specialized larvae of the Lepidoptera and their complex habits would indicate that the mining habit is probably more ancient in the Lepidoptera. On the other hand the unstable or unfixed habits of certain species, previously mentioned, would indicate that the habit is more recent.

SUMMARY OF THE HABITS OF THE TENTHREDINIDAE.*

Family	Habits	Number of Species	Distribution
Blasticotomidæ	Stem-miner	One	European
Xyelidæ	Free feeders	7 genera, about 25 N. A. species	Chiefly N. A.
Tenthredinidæ	Free-feeders, Leaf-miners, Gall-makers	About 58 genera, Numerous species	European and N. A.
Pamphilidæ	Leaf-rollers, Case makers	About 9 genera, 55 N. A. species	Peculiar to Northern Hemisphere
Megalodontidæ	Similar to Pamphilidæ	4 genera, 35 species	Europe, Asia, Northern Africa
Xiphydridæ	Borers	4 genera, about 8 N. A. species	North America and Europe
Siricidæ	Borers	5 genera, about 50 species	Confined mostly to Northern Hemisphere
Cephidæ	Borers	About 14 genera, 16 N. A. species	Inter continental

* This table has been prehared chiefly from Yuasa, (1922).

In the Hymenoptera, the leaf-mining habit seems ancient and well established. The plant feeding habit naturally preceded the more specialized boring, leaf-mining and gall-making habits. In the Tenthredinoidea the leaf-mining Hymenoptera occur together with boring and gall-making forms. In this compact group of plant feeders we find the leaf-mining species restricted to the family Tenthredinidae. The larvae seem to have reached the limit of specialization necessary for the mining habit. A comparison with the free-feeding forms shows a great reduction in legs, antennae and prolegs, the loss of setae and the development of a tuberculate cuticle. These reasons together with the fact that the mining habit occurs in

the most primitive of the Hymenoptera, seem sufficient to establish an ancient modification of the plant feeding Hymenoptera for the leaf-mining habit. The mining habit apparently arose through the usual channel, the boring habit. From the following table it is very evident that the mining habit is closely related with both the free-feeding and the boring habits. The scattered leaf-mining species found in the Tenthredinidae may be a remnant of a larger number of mining forms which have been lost through the process of evolution or have passed on to the gall-making habit.

ABUNDANCE OF DISTRIBUTION.

Not only are the number of the leaf-mining Hymenoptera small in comparison with the number of leaf-miners of other orders, but their number is insignificant when compared with the great abundance of free-living Tenthredinidae. Only thirty-nine leaf-mining species have been recorded for the world. There are, however, numerous species belonging to the leaf-mining genera of which the habits are unknown. It is possible that there are a few mining forms to be added to those that are already known. Twenty-two of the thirty-nine known species occur in North America. The remaining species are limited chiefly to the Northern hemisphere, although there are two records from South America.

Leaf-mining Hymenoptera are found in the subfamilies Phyllotominae, Holocampinae, Dineurinae, Scolioneurinae, Fenusinae and Schizocerinae. The Fenusinae and the Scolioneurinae, as far as the writer knows, are composed entirely of leaf-mining forms. Phyllotominae was divided by MacGillivray into two tribes Phyllotomini and Phlebatrophini. The former are leaf-skeletonizers, the latter, leaf-miners. The Schizocerinae may also be composed entirely of leaf-mining forms. The remaining subfamilies each have a single leaf-mining species.

Many of the species in the genera concerned have been transferred to other or to new genera. These changes, no doubt, explain certain discrepancies that exist in literature concerning the habits of a particular genus or subfamily. For instance, the separation by MacGillivray (1909) of certain species of Phyllotoma and the placing of them in a new genus Phlebatrophia changes our conception of the habits of the genus Phyllotoma. Other changes have been made which are worthy of note.

Konow (1886) removed certain species of Blennocampa, placing them in a new genus Entodecta, and again (1890) the remaining species were put in a new genus Scolioneura. Forbes (1885) erected Metallus to include certain Scolioneura. Likewise the old genus Fenusa has been divided; certain species have been transferred to the genus Kaliofenusa Mac G. (=Kaliosysphinga Tischb.), others to Fenella Westw., and some to Fenusella Enslin (1914). In summarizing the habits of these groups one must be careful to designate the limits of the genera or subfamilies with which he is concerned.

A Synopsis of the Leaf-Mining Genera of Hymenoptera.*

Family Subfamily	Genus	Distribution	No. Desc. species	No. Mining Species
Blasticotomidæ	Blasticotoma	Eur.	1	1†
Tenthredinidæ				
Phyllotominæ	Phyllotoma	Eur.	6	6
	Phlebatrophia	Eur., N. A.	2	2
Holocampinæ	Heptamelus	Eur.	1	1†
Dineurinæ	Pelmatopus	Eur.	6	4
Scolioneurinæ	Entodecta	Eur., N. A.	6	2
	Scolioneura	Eur., N. A., S. A.	7	6
	Metallus	N. A.	5	4
	Parabates	N. A.	2	0
	Polybates	N. A.	1	0
Fenusinæ	Profenusa	N. A.	1	1
	Fenusa	Eur., N. A.?	3	3
	Kaliofenusa	Eur., N. A.	2	2
	Messa	Eur., N. A.	1	1
	Fenusella	Eur.	11	3
	Fenella	Eur.	4	2
Schizocerinæ	Schizocerus	Eur., N. A. .S. A.	22	2 or 3

*The writer has followed Enslin (1917) for the synonomy of European species and Konow (1905), Rohwer and MacGillivray for the synonomy of the North American species.

†Petiole miners.

Discussion of Life-Histories.

EGGS.

Considerable difference of opinion exists concerning oviposition in the Tenthredinidae. MacGillivray (1913) states that the eggs of all the Tenthredinidae are inserted in the tissues of the plant. If this is true all the Tenthredinidae would, in a sense, be leaf-miners as the external feeders would find it neces-

sary to eat their way to the surface. From a review of the habits of the North American species it appears that they all lay their eggs within the leaves. In studying the European species the situation seems different. Healy (1869) describes the oviposition of *Phyllotoma fulginosa*[1] and *Fenusa ulmi* Newm.,[2] stating that they lay their eggs on the surface of the leaf and the young larvae work their way into the leaf. He further remarks that *Fenusa ulmi* lays its eggs on the under side of the leaf. Likewise, Cameron (1882) describes the egg laying habits of Phyllotoma as follows: "The female lays her eggs on the top or sides of the leaf. When the young larva escapes from the egg it eats its way into the parenchyma and soon eats an irregular blotch between the lower and upper epidermis." The Tenthredinidae are provided with a very specialized ovipositor for laying their eggs in the wood or leaves of plants and it is certainly a grave question why certain species should lay their eggs upon the surface of the leaf.

MacGillivray (1913) has given an excellent account of the eggs of the Tenthredinidae. They are oval, flattened and usually whitish in color. They swell to twice their size, pushing the surface of the leaf so that it appears to be covered with little mounds. The egg may project from the slit through which it was laid. The writer has also noticed that the leaf often becomes discolored about the eggs rendering them more conspicuous than when first laid.

LARVAE.

The larvae are strikingly different from the free-feeding larvae of the Tenthredinidae and one can see at a glance that considerable modification has taken place fitting them for the leaf-mining habit. They resemble, somewhat, the boring species, but are more flattened in form. They differ from the free-feeding forms in lacking brilliant colors, hairs and spines. There is a tendency to a reduction of the antennae and the thoracic legs and a great reduction of the prolegs, which are represented by mere swellings. A single ocellus on each side, characteristic of the Tenthredinidae, and the absence of the adfrontal sclerites, aid in separating them from the leaf-mining Lepidoptera. The location of the thoracic spiracles on the

[1] *Fulginosa* (=*pumila* Kl.) [2] *ulmi* Newm., could not be located.

prothorax in the Hymenoptera and on the mesothorax in the Coleoptera is a means of distinguishing these two orders. The position of the thoracic spiracles in the Lepidoptera are the same as they are in the Hymenoptera and will not aid in separating these orders. The shape of the head, however, is valuable. In the Hymenoptera the posterior half of the head is pointed and somewhat heart-shaped. In the Coleoptera it is always biforked. In the Lepidoptera it may be biforked, but it is never distinctly pointed as it is in the Hymenoptera.

Yuasa (1922) characterizes the leaf-mining forms as follows: "Body somewhat depressed, head sometimes distinctly depressed and mouthparts directed cephalo-ventrad, thoracic legs small, modified number of segments reduced to four or to one, legs sometimes entirely fleshy, conical or mamma-like, with or without tarsal claws, mouth parts sometimes modified, labial and maxillary palpi with reduced number of segments, annulation sometimes obsolete."

MINES.

As far as the writer is aware, the mines of the Hymenoptera are large blotches with their surfaces little or not at all elevated. The larvae are voracious feeders, eating the parenchyma of the leaf and leaving only the two epidermal layers. They have a peculiar habit of feeding much after the fashion of leaf-skeletonizers, leaving the fibrovascular bundles and the larger veins as a net-like structure on the epidermis of the leaf. They might be called internal skeletonizers. The parenchyma is so completely eaten out that the resulting mine appears as a thin transparent spot in the leaf, disclosing the larva within. The writer has noticed that upon succulent leaves, as the violet, the mine when complete, shrivels and distorts the leaf. Healy (1863) described the mine of *Phyllotoma tormentillae*[1] as somewhat contorted, nepticula-like, with a narrow track of frass in the center, later the blotch is formed. Dyar (1897) describes a species which is apparently an external feeder, but which "eats a curious winding slit down into the leaf." He does not mention the mining habits in further detail.

As a rule the leaf-mining Hymenoptera complete their development in a single leaf, but Dyar (1900) mentions the

[1] A synonym of *nigrita* Westw.

habits of *Schizocerus zabriskiei*, which leaves its mine to enter another when its food supply is exhausted. This habit is quite common in certain leaf-mining Diptera and Lepidoptera, but is apparently rare in the Hymenoptera.

In most cases the leaf-mining Hymenoptera make no provision for the disposal of their frass. It is usually scattered in patches throughout the abandoned part of the mine. Frequently it is located in little patches in the angle formed by two of the larger veins. Cameron (1882) mentions the interesting habits of a species of Phyllotoma which cuts a hole at the edge of the leaf and ejects its frass. This habit is common in some of the Lepidoptera, but is not known to occur in the Diptera or Coleoptera.

As a rule only one larva is found in a single mine. When the larvae hatch from individual eggs, each starts a separate mine. In the course of their wanderings they sooner or later interfere with each other and find themselves within a common blotch mine. Some females lay but one or two eggs in a leaf in which case the larvae continue to mine as separate larvae. Others lay several eggs upon a single leaf and one may ultimately find five or six larvae within a single mine.

PUPAE AND COCOONS.

The pupae present nothing unusual, being of the exarate type, with the wings and legs free, but enclosed in more or less sac-like sheaths. The majority of the leaf-mining forms construct compact silken cocoons in the ground, often incorporating particles of earth in the cocoon. Some, however, pupate in the ground without the construction of a cocoon, while the Phyllotominae construct cocoons within their mines.

There are usually two generations a year, although some of the North American forms have but one generation. MacGillivray (1913) states that, with the exception of the Tenthredinidae, the Tenthredinoidea are two brooded. Cameron (1882) states that Phyllotoma, Fenusa and Scolioneura are two brooded.

ADULTS.

The leaf-mining species of the Tenthredinoidea comprise a group quite distinct from all other Hymenoptera. They are the most generalized of the Hymenoptera, with primitive wing

venation, but a highly specialized ovipositor fitting the group for its plant feeding habit, as the great majority insert their eggs within plant tissue. The basal segments of the abdomen are similar in form and the abdomen is broadly joined to the thorax.

PHYLLOTOMINAE.

This subfamily was divided by MacGillivray into two tribes, Phyllotomini and Phlebatrophini. The former he described as skeletonizers, thoracic legs of the larvae with claws and the latter as leaf miners, thoracic legs without claws. Phlebatrophini contains two genera, Phyllotoma, which is distinctly European, and Phlebatrophia, which is neartic. The two genera contain eight described species, all of which are known to mine leaves.

Perhaps no workers have added more to our knowledge of the habits of this group than Brischke and Zaddach (1883). Healy (1878) and Cameron (1882) have likewise contributed considerable notes of interest. The habits of Phyllotoma and Phlebatrophia differ in certain marked respects from all other leaf-mining Hymenoptera. They have a peculiar habit of spinning a flat cocoon within their mine, cutting a circular piece from the upper epidermis which may or may not fall to the ground. The larvae remain in these cocoons until the following Spring, when transformation takes place and the adults emerge. Usually but one or two mines are found upon a single leaf. The European species have two generations a year.

An interesting habit was noted by Healy (1878) concerning the larva of *P. melanopyga* Kl.,[1] mining *Salix caprea*. It works its way to the edge of the leaf and cuts a slit at the side of the mine through which it ejects its frass. This is the only case on record of a definite attempt of a leaf mining Hymenopterous larva to dispose of its frass. He also states that the same species lays its eggs upon the surface of the leaf, a habit that is strange for the Tenthredinoidea.

The larva of *P.* (*tormentillae*) *nigrita* Westw., according to Healy (1878) forms a contorted nepticula-like mine one quarter of an inch long, with a narrow frass line in the center. Later it forms a small greenish blotch mine. The formation of a short linear tract preceding the blotch mine is common in the Hymenoptera, although the original linear tract is very often obliterated by the blotch formed later.

[1] A synonym of *microcephala* Kl.

HOLOCAMPINAE.

A single species *Heptamelus ochroleucus* Hal., a petiole miner of *Athyrium felix femina*, occurs in this group. DeMeijere (1911) pointed out the habits of this species. There are no true leaf-mining forms as far as the writer is aware.

DINEURINAE.

This subfamily contains a single genus *Pelmatopus* with six described species from Europe. Our knowledge of the habits of this group is still imperfect, nevertheless four of them are known to be leaf-miners. There is ample opportunity for studying life-histories in this group.

SCOLIONEURINAE.

This small subfamily of approximately twenty-one North American and European species contains only twelve species known to mine leaves. The habits of the remaining species are unknown, but no doubt all are leaf-mining species. It is interesting to note that all the leaf-mining genera are distributed in the Northern Hemisphere, except *Scolioneura*, which has one species from Chili.

Our knowledge of the habits of this subfamily is none too complete. Forbes (1885) and Houghton (1908) give studies of the blackberry leaf-miner, *Scolioneura capitalis* Norton. The writer has made observations on a species of Scolioneura mining leaves of violet.

The mines are of the blotch type with no definite shape. The eggs are laid within the tissues of the leaves and several young larvae are often found on a single leaf. The mature larvae drop to the ground and make silken cocoons, remaining as larvae until the following Spring, when transformation occurs and the adults emerge. In *Scolioneura capitalis* there are two broods a year.

There are some structural characters in the larvae of the Scolioneurinae which are distinctive. The thoracic legs are four or five jointed with sharp claws, the larva-pods are rudimentary and reduced to mere swellings on the second to seventh segments, inclusive. The antennae are one segmented. There are nine pairs of spiracles, one pair on the prothorax and eight pairs on the abdomen, commencing with the first abdominal

segment. In Scolioneura the mandibles have several sharp teeth and the maxillary palpi are two segmented. In Metallus the mandibles have no definite teeth and the maxillary palpi are three segmented.

FENUSINAE.

The members of this subfamily are probably all leaf-miners. It is represented by four genera in North America and two genera which are peculiar to Europe. Twelve of the twenty-two described species are known to mine leaves. Several are of economic importance; *Fenusa dohrni* Tischb., the alder leaf-miner, *Kaliofenusa ulmi* Sund., the elm leaf-miner and *Profenusa collaris* MacG., the Cherry and Hawthorn leaf-miners.

The habits of the elm leaf-miner have been studied by Herrick (1913) and the Cherry and Hawthorn leaf-miner by Parrott and Fulton (1915). Cameron (1882) described the habits of the following species: *nigrita* Westw., *melanopoda* Thoms., *pumila* Kl., *ulmi* Sund., *hortulana* Kl., *pygmaea* Kl., and *albipes* Cam., all of which are recognized today to belong to Fenusinae. In addition we have the life-history studies of *dorhni* Tischb. and *curtus* Norton, from North America.

The eggs are usually laid within the tissues of the leaf, although Healy (1868) states that *fulginosa*, now a synonym of *pumila* Kl., oviposits on the surface of the leaf. Several eggs may be laid upon a single leaf, so that from one to fourteen larvae may be found in one leaf. The mines vary from small blotch mines to large irregular blotch mines which are sometimes blisterlike as in *collaris* MacG. Very often the original linear beginning of the mine is visible if not obliterated by the blotch forming later. The mature larvae all descend to the ground to pupate. The majority form brownish silken cocoons, with the addition, sometimes, of particles of earth. One species at least *pumila* Kl., according to Cameron (1882), constructs no cocoon, but pupates in the ground. The European species are apparently two brooded, but the majority of the North American species are one brooded.

SCHIZOCERINAE.

Our knowledge of the habits of this subfamily are still quite incomplete. The genus Schizocerus Lep., is apparently composed entirely of leaf-mining forms. Yuasa (1922) speaks as though all the species of Schizocerinae may be leaf-miners.

According to Konow (1905) there are twenty-one described species of Schizocerus which are distributed as follows: four European, ten North American and eight South American species. With the addition of a species, *S. zabriskiei* Ashm., not listed by Konow, we can increase the number to twenty-two. There are only two or three forms known to be leaf miners.

For our knowledge of the habits of the genus Schizocerus, we must rely chiefly upon Dyar, who has published several short papers upon this group. According to Dyar (1897) *S. pruni-vorus* Marl., lays its eggs in a pyriform slit under the lower epidermis at the middle of one edge of the leaf. The larva hatches and eats a curious winding slit down into the leaf, later this reaches the edge. The larva drops to the ground, where it makes a cocoon of yellowish silk. Dyar (1893) describes the habits of *S. tristis fumipennis* n. var., feeding on *Hosackia quadriflora*, but does not state whether it mines. It is interesting to note that the cocoon is found on the back of the leaf. It is oblong, rounded and composed of coarse silk of irregular texture and not compact enough to be opaque. In 1900 he gives some interesting notes on *S. zabriskiei* Ashm., the larvae of which enter another leaf when the food supply is exhausted.

As we come to a better knowledge of this genus, we may find some remarkable deviations from the regular method of leaf-mining in the Hymenoptera.

A List of the Leaf-Mining Hymenoptera and Their Food Plants.

BLASTICOTOMIDÆ.

Blasticoma filiceti Kl., a petiole miner in Anthyrium felix-femina. Europe (De meijere, 1911).

TENTHREDINIDÆ.

SCOLIONEURINÆ.

Entodecta alaskana Kcd. food plant unknown, Alaska (MacGillivray, 1909). *E. gei* Brischke (=*decolor* Knw.) on Geum urbanum, Europe (Brischke, 1880). *E. beckeri* Knw., food plant unknown, Europe (Konow, 1905). *E. humilis* Knw., food plant unknown, Alaska (MacGillivray, 1909). *E. pumilis* Kl., (=*pumilio* Htg., *rubi* Boie., *lanceolatus* Thoms., *pumila* Weales., *pumilio* Cam.) on Rubus fructicosus and R. idæus, Europe (Cameron, 1882), on Rubus cæsius, R. dumetorum, R. discolor, Germany (Kaltenbacgh, 1872), on Geum urbanum, Europe (Zaddach,). *E. umbrosa* Eversm., food plant unknown, Europe (Konow, 1890).

Metallus bethunei MacG., on Rubus species (Blackberry), New Haven, Conn. (Britton, 1916). *M. capitalis* Norton., on Rubus species (Blackberry), Delaware, (Houghton, 1908), New York, Conn., Ill., (Norton, 1867), Mo., (Riley). *M. canadensis* Marl., food plant unknown, Canada (Marlatt, 1895). *M. rohweri* MacG., on Rubus species (Blackberry), Block Is., Rhode Is., (MacGillivray 1909). *M. rubi*

Forbes., on Rubus species (Blackberry), Ill., (Forbes, 1885), N. H., Conn., (Britton, 1916). *M.* species on Rubus species, Ithaca, N. Y., Arendtsville, Pa., (writer).

Parabates histrionicus MacG. food plant unknown, Wash., Colo., (MacGillivray, 1909). *P. inspiratus* MacG., food plant unknown, Nevada (MacGillivray, 1909).

Polybates slossonæ Mac G., food plant unknown, New H. (MacGillivray, 1909).

Scolioneura betulæ Zadd., (=*vicina* Knw., *tenuicornis* Steph.) on Betula alba, Germany (Brischke, 1980), on Betula pubescens, Germany, (Konow, 1901), on Betula species, Sweden (Tullgren, 1908). *S. betuleti* Kl., on Betula alba and B. pubescens, Europe (Konow, 1901), on Betula species Sweden (Tullgren, 1908). *S. nana* Kl., (=*quercus* Cam., *intercus* Zett.) on Quercus species, Europe (Enslin, 1914). *S. nigricans* Kl., (=*mellita* Newm.?) on Betula species, Germany, England (Enslin, 1914). *S. populi* Marl., probably on Populus fremontii, Las Cruces, N. M. (Marlatt, 1895). *S. surosa* Knw., food plant unknown, Europe, (Konow, 1905). *S. tenella* Kl., (=*tiliæ* Kaltb., *tenuicornis* Brischke., *albida* Thoms., *hylotomoides* Lep.) on Tilia europæa and T. platyphyllos, Europe (Kaltenbach, 1872), on Tilia ulmifolia, Europe (Enslin, 1914). *S.* species on Viola species, Arendtsville, Pa. (Writer.)

FENUSINÆ.

Fenusa curta Norton., on Quercus macrocarpa, Plattsburg, N. Y. (Dyar, 1895). *F. dohrni* Tischb. (=*nigraicns* Thoms., *melanopoda* Cam., *pumila* Brischke) on Alnus glutinosa, Europe (Brischke, 1880) N. A., (Konow, 1901), on Alnus incana, Europe (Konow, 1901) on Alnus vulgaris N. A. (Britton, 1916), on Alnus species, Europe (Cameron, 1882). *F. varipes* Dyar., food plant unknown, N. A. (Dyar, 1895).

Fenusella albipes Cam. on Rosa species (Rose), Europe (Cameron, 1882). *F. excisa* Knw., food plant unknown, Europe (Enslin, 1914), *F. glaucopis* Knw., food plant unknown, Europe (Enslin, 1914). *F. nigripes* Knw., food plant unknown, Europe (Enslin, 1914). *F. pygmæa* Kl., (=*pygmæa* Ste.) on Agrimonia eupatoria, Europe (Healy, 1868), on Quercus species, Europe (Cameron, 1882). *F. recta* Thoms., *F. steusloffi* Knw., *F. thomsoni* Knw., (*pumilio* Thoms.) and *F. tirolensis* Enslin, food plants unknown, Europe (Enslin, 1914). *F. wuestneii* Knw., on *Salix* species, Europe (Enslin, 1917).

Kaliofenusa pumila Kl., (=*intercus* Fall., *pusilla* Lep., *Pygmæa* Zett., *tantilla* Costa, *fulginosa* Healy., *minima* Brischke.) on Betula populifolia, Conn. (Britton, 1916), on Betula alba, Europe (Brischke, 1883), on Betula pubescens, Europe (Konow, 1901), on Geum urbanum, Rubus cæsius, R. dumetorum and R. idæus, Europe (Kaltenbach, 1872). *K. ulmi* Sund., (=*intermedia* Thoms.) on Ulmus campestris and U. montana, Europe (Cameron, 1882), on Ulmus species (Scotch, English and Amperdown Elm) Ithaca, N. Y. (Mac Gillivray, 1909).

Profenusa clolaris MacG., on Prunus cerasis and Cratægus species, N. A. (Parrott, 1915).

Messa ambigua Norton., food plant unknown, N. A., (Mac Gillivray, 1909). *M. hortulana* Kl., (=*hortulana* Cam., *dæderleine* Stef., *ticinensis* Magr.), on Populus nigra, Europe (Cameron, 1882), on Acer platanoides, Europe (Brischke, 1883), on Acer campestre, Europe (Konow, 1901).

Fenella minuta Thoms., food plant unknown, Europe (Enslin, 1914). *F. monilicornis* Thoms., food plant unknown, Europe (Enslin, 1914). *F. nigrita* Westw., (=*intercus* Vill., *minutissima* Costa., *tirmentillæ*, *pygmæa* Healy., *agrimoniæ* Brischke.), on Agrimonia eupatoria and Potentilla reptans, Europe (Cameron, 1882), on Tormentilla reptans, Europe (Healy, 1868). *F. westwoodi* Cam., on Betula species, Europe (Cameron, 1882).

PHYLLOTOMINÆ.

Phyllotoma acris McLachl. (nec. Kaltb.), on Acer campestris and A. pseudoplatanus, Europe (Kaltenbach, 1872). *P. fumipennis* Cam., on Acer species, Europe (Enslin, 1917). *P. leucomelnena* Kl. (=*maxima* Strobl?) food plant unknown, Europe (Enslin, 1914). *P. microcephala* Kl., (=*melanopyga* Healy.), on Alnus glutinosa, Europe (Healy, 1868), on Salix alba, Europe (Kaltenbach, 1872), on Salix caprea, Europe (Brischke, 1883), on Salix cinerea, S. russeliana and S. viminalis,

Europe (Konow, 1901). *P. ochropoda* Kl., (=*fuscipennis* Steph., *pinguis* Voll., *nigrescens* Gradl., *costæ* Costa.), on Populus tremula, Europe (Cameron, 1882). *P. vagans* Fall., (=*melanopoda* Kl., *leucopoda* Dahlb.), on Alnus glutinosa, Europe (Konow, 1901), on Alnus incana, Europe (Brischke, 1883), on Salix caprea, Europe (Healy, 1868), on Alnus species, Europe (Kaltenbach, 1872).

Phlebatrophia mathesoni MacG., on Betula species, N. S., (MacGillivray, 1909), *P. nemorata* Fall., (=*parviceps* Newm., *tenella* Zadd.), on Betula alba, Europe (Konow, 1901) on Betula pubescens, Europe (Konow, 1901) on Betula species, Europe (Cameron, 1882), N. A. (MacGillivray, 1909).

HOLOCAMPINÆ.

Heptamelus ochroleucus Hal., (=*dahlbomi* Thoms.) mines in petiole of Anthyris, felix femmina, Europe (De meijere, 1911).

DINEURINÆ.

Pelmatopus enslini Hering., on Trollius europæus, Europe (Hering, 1922). *P. fusculus* Kl., (=*despetca, minuta* Htg.) on Ranunculus auricomus and R. repens, Europe, (Cameron, 1882). *P. hepaticæ* Brischke., on Hepatica triloba, Europe (Brischke, 1880). *P. mentiens* Thoms., on Hepatica triloba, Europe (Enslin, 1917). *P. parvulus* Kl., (=*minuta* Lep.) food plant unknown, Europe (Enslin, 1914).

SCHIZOCERINÆ.

Schizocerus ebenus and *S. privatus*, food plants unknown, N. A. (Dyar, 1895). *S. tristis* var. *fumipennis* Dyar., on Hosackia grandiflora, Calif., (Dyar, 1923). *S. pruinivorus* Marl., on Prunus species, N. A. (Dyar, 1897). *S. zabriskei* Ashm., L. I., N. Y. (Dyar, 1900).

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aceris Kaltb. (MacLachl.) Phyllotoma.
agrimoniæ Brischke. Fenella.
alaskana Kcd. Entodecta.
albida Thoms. Scolioneura.
albipes Cam. Fenusella.
amaura Klg. Phyllotoma.
ambigua Norton. Fenusa.
bethunei MacG. Metallus.
betulæ Zadd. Scolioneura.
betuleti Kl. Scolioneura.
capitalis Norton. Metallus.
collaris MacG. Profenusa.
costæ Costa. Phyllotoma.
curta Norton. Fenusa.
dahlbomi Thoms. Heptamelus.
decolor Knw. Entodecta.
despectus Htg. Pelmatopus.
doederleini Stef. Fenusa.
dohrni Tischb. Fenusa.
excisa Knw. Fenusella.
filiceti Kl. Blasticotoma.
fulginosa Healy. Kaliofenusa.
fumipennis Cam. Phyllotoma.
fuscipennis Steph. Phyllotoma.
fusculus Kl. Pelmatopus.
glaucopis Knw. Fenusella.
gei Brischke. Entodecta.
hepaticae Brischke. Pelmatopus.
hortulana Kl. Fenusa.
humilis Knw. Entodecta.
hylotomoides Lep. Scolioneura.
intercus Fall. Kaliofenusa.
intercus Vill. Fenella.
intercus Zett. Scolioneura.
intermedia Thoms. Kaliofenusa.
lanceolatus Thoms. Entodecta.
leucomela Kl. Phyllotoma.
leucopoda Dahlb. Phyllotoma.
mathosoni MacG. Phlebatrophia.
maxima Strobl? Phyllotoma.
melanopoda Cam. Fenusa.
malanopoda Thoms. ?
melanopoda Knw. Kaliofenusa.
melanopyga Healy. Phyllotoma.
melanopyga Kl. Phyllotoma.
mellita Newm? Scolioneura.
mentiens Thoms. Pelmatopus.
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minima Brischke. Kaliofenusa.
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nemorata Fall. Phyllotoma.
nigrescens Gradl. Phyllotoma.
nigricans Kl. Scolioneura.
nigricans Thoms. Kaliofenusa.
nigricans Thoms. Fenusa.

* Synonyms are in italics.

nigripes Knw. Fenusella.
nigrita Westw. Fenella.
ochroleucus Hal. Heptamelus.
ochroleucus Steph. Heptamelus.
ochropoda Kl. Phyllotoma.
ochropodus Ste. Phyllotoma.
ochropodus Thoms. Phyllotoma.
ochropus Kl. Phyllotoma.
parviceps Newm. Phyllotoma.
pævulus Kl. Pelmatopus.
pinguis Vollenh. Phyllotoma.
prunivorus Marl. Schizocerus.
pumila Kl. Kaliofenusa.
pumila Brischke. Fenusa.
pumilio Htg. Entodecta.
pumilio Thoms. Fenusella.
pumilus Kl. Entodecta.
pusilla Lep. Kaliofenusa.
pygmæa Healy. Fenella.
pygmæa Hrtg. Fenusa.
pygmæa Kl. Fenusella.
pygmæa Ste. Fenusa.
pygmæa Zett. Kaliofenusa.
quercus Cam. Scolioneura.
recta Thoms. Fenusella.
rubi Boie. Entodecta.
rubi Forbes. Metallus.
simulans Cam. Pelmatopus.
surosa Knw. Scolioneura.
steusloffi Knw. Fenusella.
tantilla Costa. Kaliofenusa.
tenella Kl. Scolioneura.
tenella Zadd. Phyllotoma.
tenuicornis of authors nec. Kl. Scolioneura.
tenuicornis Steph. Scolioneura.
thomsoni Knw. Fenusella.
ticinensis Magr. Fenusa.
tiliæ Kaltb. Scolioneura.
tirolensis Enslin. Fenusella.
tormentillæ Healy. Fenella.
tristis var. fumipennis Dyar. Schizocerus.
ulmi Sund. Kaliofenusa.
ulmi Newm. ?
umbrosus Eversm. Entodecta.
vagans Fall. Phyllotoma.
vagans Thoms. Phyllotoma.
varipes probably Kirby Fenusa.
vicina Knw. Scolioneura.
westwoodi Cam. Fenella.
wuestneii Knw. Fenusella.
wuestneii Knw. Phyllotoma.
zabriskei Ashm. Schizocerus.

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EXPLANATION OF PLATES.

Plate XXIX.*

Fig. 1. *Scolioneura capitalis* Norton., pupa and cocoons.
Fig. 2. *Fenusa dohrni* Tischb.
Fig. 3. *Kaliofenusa ulmi* Sund.
Fig. 4. *Kaliofenusa ulmi* Sund.
Fig. 5. *Scolioneura capitalis* Norton.
Fig. 6. *Scolioneura capitalis* Norton., larvae.

Plate XXX.*

Fig. 1. Mine of *Profenusa collaris* MacG., on cherry (after Parrott and Fulton).
Fig. 2. Mine of *Profenusa collaris* MacG., on hawthorn (after Parrott and Fulton).
Fig. 3. Mine of *Kaliofenusa ulmi* Sund., on elm.
Fig. 4. Mine of *Fenusa dohrni* Tischb., on alder.
Fig. 5. Mine of *Scolioneura capitalis* Norton on Blackberry.

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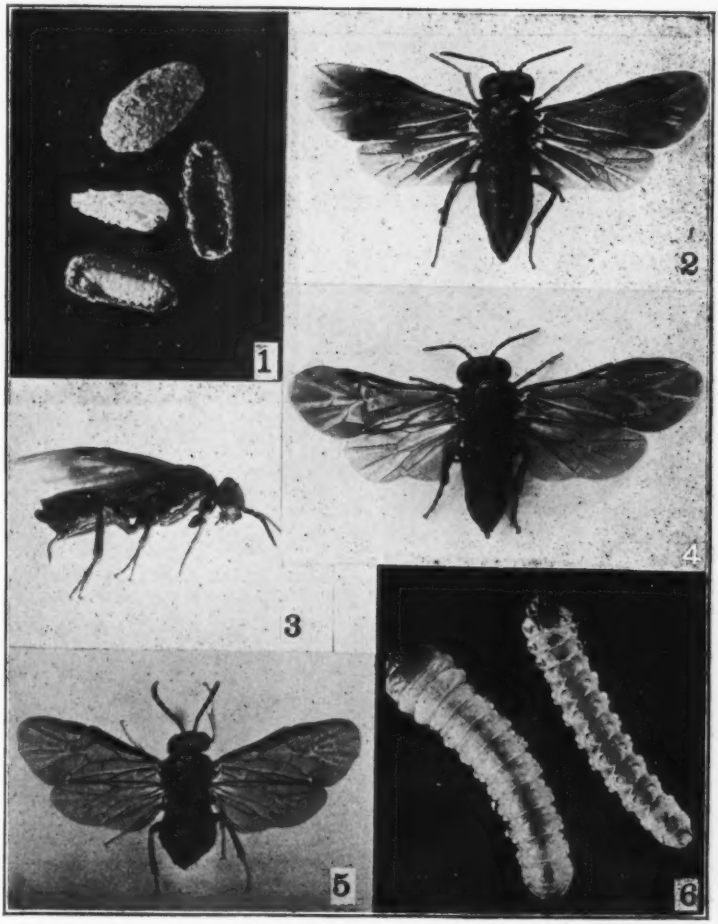
*All photographs were taken from negatives in the collection of the Cornell Agricultural Experiment Station except those otherwise designated.



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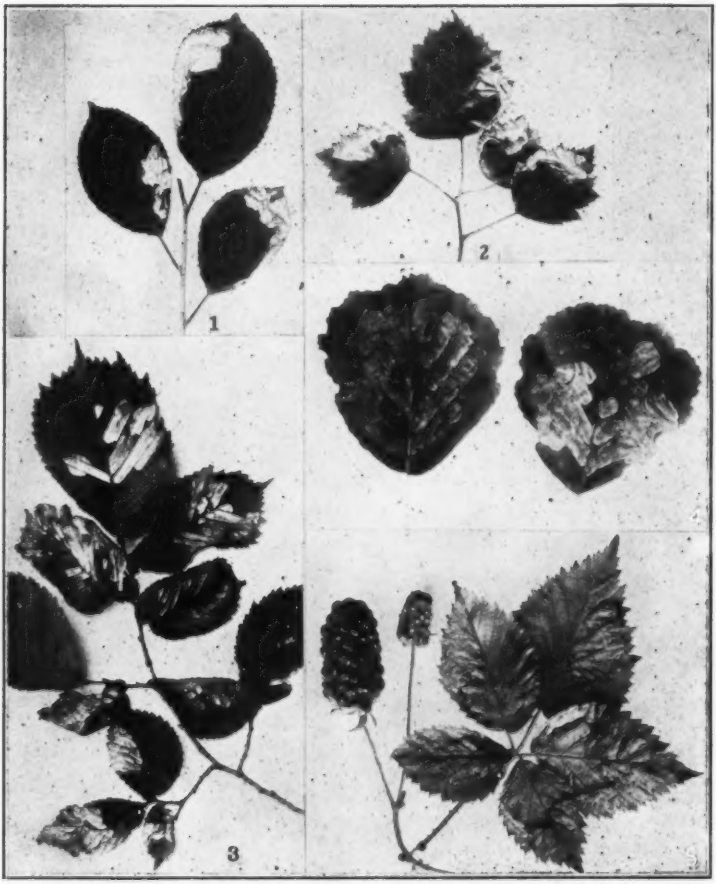

S. W. Frost

A NEW NOTONECTA FROM CHINA.

Notonecta suensoni sp. new. (Hemiptera-Notonectidæ).

H. B. HUNGERFORD
University of Kansas.

In a collection of aquatic insects sent to me from China by Dr. Suenson, I find a single pair of an undescribed species of backswimmer. It represents a smaller and more slender species than one is accustomed to see from the orient. At first glance it reminds one of *Notonecta lactitans* Kirk., a species which lives in South Africa. It is, however, larger and structurally quite different. From China one expects to see handsome, red and black species as large, or larger, than our North American *Notonecta irrorata* Uhler. This new species is pale in color and the male is but a trifle broader than our common *Notonecta undulata* Say. Its greater length makes it a relatively more slender species than any save *Notonecta lactitans* Kirkaldy.

Notonecta suensoni sp. new.

Size: Length of male, 12.5 mm., of female, 13.8 mm.; width across the eyes, male 2.28 mm., female 3 mm.; width across widest part of pronotum, male 4 mm., female 4.5 mm.

Color: General color luteous. Scutellum black. Sparse silvery pubescence on hemelytra. Brownish black band along apical margin of clavus. (Caudal half of elytral suture). Slender brown line on base of clavo-corial suture and another longitudinal line on disk of corium. Margins and distal third of embolium more or less brownish. Distal portion of corium marked with two nearly quadrate brownish black areas, one before the other; the posterior one larger and both covered with conspicuous silvery hairs. Inner angle of corium and inner base of membrane embrowned. Venter black. The ventral side of the connexivum greenish.

Structural characteristics: Head long. Eyes close together at synthlipsis. Vertex : synthlipsis : : 5 : 1. Lateral margins of pronotum divergent, slightly sinuate, and narrowly explanate. Length of scutellum and elytral suture equal. Membrane twice as long as elytral suture. Legs relatively slender, the angle of the mesotrochanter produced into a long slender pointed spur.

Described from specimens taken at Shanghai, China, by Dr. E. Suenson. Male holotype and female allotype in writer's collection.

Comparative Notes: This species is very distinct from the other species of the orient. It differs from all of them by its pale color and more slender shape. It differs from *N. montandoni* Kirk., *N. violacea* Kirk., *N. kirkaldyi* Martin and the *N. glauca* group in having the mesotrochanter plainly spurred. In this respect it is like *N. trigutata* Motsch. and *N. chinensis* Fallou, from which it is readily separated by its longer and more slender spur. The claspers of the male genital bulb also distinguish this species. They are truncate at tip.

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